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Child Eye Health in Nampula, Mozambique and Ireland

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CHILD EYE HEALTH

IN

NAMPULA, MOZAMBIQUE

AND

IRELAND

Aoife Phelan BSc (Hons) Optom FAOI

MPhil

Dublin Institute of Technology

February 2016
Abstract

Purpose:
To examine child eye health, in particular, visual impairment (VI), uncorrected refractive error (URE) and strabismus in two targeted cohorts of children in Mozambique and Ireland.

Methods:
The right eye spherical equivalent (SE) value was used for analysis of the refractive error (RE). RE was assessed using non cycloplegic retinoscopy (NCR) and cycloplegic autorefraction (CAR) in Mozambique and Ireland respectively. RE was categorised as myopia and hyperopia (Mozambique: SE ≤ -1.00D and > +1.50D, Ireland: SE ≤ -0.50D or ≥ +2.00D) and astigmatism (cylinder ≤ -0.75D). Qualitative data based on grounded theory was captured on local factors affecting child eye health and barriers to teacher vision screening in Nampula.

Results:
Myopia, hyperopia and astigmatism were present in 2.4%, 6.5% and 6.4% respectively of school children screened in Mozambique. None of the children were wearing spectacles. Ocular abnormalities were present in 12% of children. Myopia and hyperopia and astigmatism were present in 23%, 38% and 31% respectively of school children attending Irish optometry practices.

Conclusion:
VI and RE were present in both cohorts of children. Both in Mozambique and Ireland personnel proficient in NCR and ophthalmoscopy are required to increase the detection rate for hyperopia and ocular abnormalities during school eye health screenings.
Declaration page

I certify that this thesis which I now submit for examination for the award of Master of Philosophy, is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate study by research of the Dublin Institute of Technology and has not been submitted in whole or in part for another award in any other third level institution.

The work reported on in this thesis conforms to the principles and requirements of the DIT's guidelines for ethics in research.

DIT has permission to keep, lend or copy this thesis in whole or in part, on condition that any such use of the material of the thesis be duly acknowledged.

Signature:  

30th August 2015
Acknowledgements

To my husband John, thank you for your patience, common sense, kindness and love. I am eternally grateful to Ellen Mae, my parents, sisters, brothers in law, John’s family, nephews, nieces and friends for the many ways they have helped me get to this point in my life.

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To my fellow researchers Stephen Thompson, Kajal Shah, Vanessa Moodley and Diane Wallace van Staden it’s been a pleasure and an honour to work with you. I could not have wished for better companions on this journey. I wish you all the best of luck in your future endeavours.

To the staff, students and graduates of the Dublin Institute of Technology and University of Lúrio optometry programmes and participating Irish optometrists thank you for assisting with data collection and supporting the research. This thesis is the result of an enormous effort by optometrists from Ireland, Columbia, Spain, Portugal, United Kingdom, South Africa and Mozambique.

My hope is that this thesis will contribute to the Vision 2020 Initiative; this would be the best way to show my appreciation to the children in Mozambique and Ireland who took part in this study.

Dedication

This thesis is dedicated to John and Ellen Mae Hegarty and David Phelan.
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<td>Cylinder</td>
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<tr>
<td>CAR</td>
<td>Cycloplegic Autorefraction</td>
</tr>
<tr>
<td>CEH</td>
<td>Child Eye Health</td>
</tr>
<tr>
<td>CR</td>
<td>Cycloplegic Refraction</td>
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<td>CRet</td>
<td>Cycloplegic Retinoscopy</td>
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<td>D</td>
<td>Dioptré</td>
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<tr>
<td>DS</td>
<td>Dioptré Sphere</td>
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<td>DC</td>
<td>Dioptré Cylinder</td>
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<td>F</td>
<td>Female</td>
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<tr>
<td>HSE</td>
<td>Health Service Executive</td>
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<tr>
<td>LogMAR</td>
<td>Logarithm of Minimum Angle of Resolution</td>
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<td>M</td>
<td>Male</td>
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<tr>
<td>MAR</td>
<td>Minimum Angle of Resolution</td>
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<td>NCAR</td>
<td>Noncycloplegic Auto Refraction</td>
</tr>
<tr>
<td>NCR</td>
<td>Noncycloplegic Retinoscopy</td>
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<tr>
<td>NCSR</td>
<td>Noncycloplegic Subjective Refraction</td>
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<tr>
<td>NGDO</td>
<td>Non-Governmental Development Organisation</td>
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<tr>
<td>RAAB</td>
<td>Rapid Assessment of Avoidable Blindness</td>
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<tr>
<td>RARE</td>
<td>Rapid Assessment of Refractive Error</td>
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<td>RE</td>
<td>Refractive error</td>
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<td>RESC</td>
<td>Refractive Error Study in Children</td>
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<td>SD</td>
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<td>SE</td>
<td>Spherical Equivalent</td>
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<td>UNESCO</td>
<td>United Nations Educational Scientific and Cultural Organisation</td>
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<tr>
<td>UNICEF</td>
<td>United Nations Children Fund</td>
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<tr>
<td>URE</td>
<td>Uncorrected Refractive Error</td>
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<td>VA</td>
<td>Visual Acuity</td>
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<td>VI</td>
<td>Vision Impairment</td>
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1 CHAPTER ONE: INTRODUCTION

1.1 Background and context

Child Eye Health (CEH) is the collective term for all aspects of children’s eye health and vision. Children with optimal eye health have good vision and healthy eyes. Poor eye health among children, if left untreated, leads to vision impairment (VI). This thesis is concerned with different initiatives to combat CEH in Mozambique and Ireland.

The research focusses on two of the most important aspects of CEH which are VI and uncorrected refractive error (URE). The study utilises the World Health Organisation (WHO) (2015) classification of VI as all levels of VI and blindness from mild VI to no light perception. URE is defined as the need for spectacles due to the inability to focus a clear image on the retina (Dandona & Dandona 2001). URE is one of the leading causes of VI among children and adults internationally (Bourne et al. 2013, Stevens et al. 2013, Resnikoff et al. 2008 & Thulasiraj et al. 2003).

CEH is a concern in all nations but most especially in developing countries where primary health care services are not as established, Mozambique is one such nation. This thesis will examine CEH, in particular URE and VI, in Nampula city and surrounds, where children with treatable causes of VI are needlessly disabled.
CEH is also a concern where primary health care is established in developed countries like Ireland. Irish children may not be receiving eye examinations through the public system in a timely manner. The thesis also examines cases of URE and VI in Irish children presenting to private optometry practices.

The United Nations Declaration of the Rights of the Child (1959) states that “the child is entitled to education and to adequate nutrition, housing, recreation and medical services. The child shall be afforded special treatment if handicapped and the child shall in all circumstances be among the first to receive protection and relief”.

Children with undetected or untreated VI are denied not only their human right to treatment for VI but also they are, most likely, being denied their right to an education as severe VI is a major barrier to education (Bourne et al. 2004). CEH is an important public health concern which should be tackled in the immediate future as it has long term negative effects on the population and economy if ignored (Gilbert & Foster 2001).

1.2 Outline of thesis

The thesis comprises of three studies. Study 1 examines the number of children with URE and VI as detected in the first optometry led school screenings in Nampula. Study 2 uses a mixed methods approach to explore the potential for teachers in Nampula to become vision screeners for children. Study 3 examines URE, VI and strabismus among a targeted cohort of children attending Irish optometry practices for eye examinations.
Chapter two details the prevalence of VI, URE and aetiology of childhood blindness globally and more specifically in Mozambique. Chapter three introduces Nampula, Mozambique. Geographical, social and economic points relative to CEH are summarised. It outlines the current state of CEH in Mozambique. Various points of interest on CEH in Mozambique and developing countries are discussed. Chapter four introduces Ireland with supporting social and economic indicators. CEH in Ireland is discussed with contrasting VI estimates of prevalence and epidemiology to Mozambique. 

Chapter five summarises the results of the first optometry led school eye health screenings which took place in 2010 and 2012 in Nampula. It gives an insight into the amount and types of URE as determined by non cycloplegic retinoscopy (NCR) and ocular pathology among a targeted cohort of school children. Using different classifications of URE as identified through a literature review it highlights how each separate classification can influence the URE estimates.

Chapter six is a mixed methods study utilising both quantitative and qualitative data to investigate the potential for teacher vision screening and the local factors which influence CEH in Nampula. It compares teacher and optometry student vision screening results. There is a dearth of health care workers in Nampula, so teachers may be ideally placed to support the detection of children with VI and URE.
Chapter seven outlines the results of a study on the refractive error (RE) of Irish school children attending private optometric practices between March and July 2015 in Ireland. It follows on from the work on RE categories in Chapter five where RE as determined by both non cycloplegic and cyclopleged refractive techniques is classified. This chapter also assesses a small cohort of children who failed the public health system school vision screening but did not receive an eye examination through this system.

Chapter eight collates the main results of the study. It discusses the results. It offers insight into the significance of the thesis. It suggests further research.

1.3 Aims and objectives

The following section outlines the key background issues and the aims and objectives of each study.

**Study one: Vision and eye health assessment in school screenings in Mozambique**

The first optometry led school vision and eye health screening studies were conducted in 2010 and 2012 in three primary schools in Nampula in Mozambique.

Aims and objectives

1. To set up the first optometry led school screening in Nampula and evaluate the outcome.
2. To apply international classifications for URE to the NCR results of this study to estimate the amount of URE using NCR results among this targeted cohort of school children.

3. To assess the spectacle coverage rate.

Study two: teacher school vision screening and local factors affecting child eye health in Nampula.

The first investigation of teacher vision screening and local factors affecting CEH in Nampula was conducted from 2010 to 2012.

Aims and objectives

1. To assess the accuracy of teachers as vision screeners.

2. To consult with potential stakeholders in CEH in order to gain an understanding of the complex local challenges and considerations that influence CEH in Nampula.

Study three: Refractive error and strabismus in Caucasian children presenting to Irish private practice optometrists.

The first investigation of RE and VI among Irish school children attending private optometry practices for an eye examination was conducted from March to July 2015.

Aims and objectives

1. To examine the RE, VI and presence of strabismus among this cohort.

2. To classify the URE detected in the study cohort using various categories for RE.
3. Conduct a pilot study to investigate if children in this cohort who failed/passed the Health Services Executive (HSE) school vision screening had RE or strabismus.

The next chapter gives estimates of prevalence for VI and URE globally and in Mozambique. It also outlines the basic principles of a national CEH care model.
2 CHAPTER TWO: CHILD EYE HEALTH

2.1 Introduction

This chapter outlines key issues around CEH. It also summarises the aetiology of VI and URE in developing countries. Primary child eye care is discussed in the context of the ideal national CEH model. The concept of sector wide approach for health interventions is introduced. The integration of school eye health and school health to primary eye care is considered.

Definitions

RE is the collective term for myopia (the inability to see distant objects clearly due to light focussing in front of the retina), hyperopia (the inability to see objects clearly due to light focussing behind the retina), astigmatism (the inability to see objects clearly due to light not focussing as a point image on the retina) and presbyopia (diminished ability to see near objects). Visual Acuity (VA) is a measure of the smallest line on a vision chart that can be read (Rabbetts 1997).

The classification of vision varies widely. According to the WHO (2015) it was categorised based on presenting distance VA: mild or no VI; moderate VI (< 6/18 > 6/60); severe VI (< 6/60 > 3/60) and blindness (< 3/60 > 1/60 or < 1/60 > light perception or no light perception). Moderate and severe VI (< 6/18 > 3/60) and blindness (< 3/60)
are referred to as VI. In this study VI is defined as $< 6/12$ or $\geq 0.32 \logMAR$ in the better seeing eye.

### 2.2 Prevalence of uncorrected refractive error and visual impairment in children

The WHO and the International Agency for the Prevention of Blindness lead a joint global initiative “VISION 2020”. This initiative aims to eliminate avoidable blindness by 2020. It is an international membership of Non-Governmental Development Organisations (NGDOs), eye care institutions and corporations (VISION2020 2007). URE and VI are detrimental to CEH and are two of the main priorities of the VISION2020 initiative (VISION2020 2007). Rahi et al. (2010) state that it is important to detect and treat URE and eye disease early in children to minimise functional vision loss. URE can be treated very simply and cost effectively by providing a pair of spectacles (Kempen 2004).

No studies have been published to date in Mozambique and Nampula on the prevalence, incidence or aetiology of URE and VI in children. Therefore one must use global and regional studies as a guide for estimating the magnitude of the problem in Mozambique and Nampula.

According to Reshnikoff et al. (2008) globally 12.8 million children aged 5 - 15 years live with VI (presenting vision $< 6/18$ corrected to better than $6/18$) from uncorrected or ineffectually corrected RE. This represents a global prevalence of approximately 1%.
This number will increase if not addressed because of the increasing global population (Reshnikoff et al. 2004). Reshnikoff et al. report that the highest prevalence of URE is in south-east Asia and in China (2008). According to Pascolini & Mariotti (2012) in 2010 the global prevalence was estimated at 1.4 million blind and 17.5 million moderate to severe visually impaired children aged 0 - 14 years. The majority of blind and visually impaired children live in the developing world (Pascolini & Mariotti 2012, Gilbert & Muhit 2012). Poverty is a cause and effect of VI (Jaggernath et al. 2014). The negative effect on the economy that is caused by the number of blind years (years living with blindness) from childhood blindness is second solely to blind years from adult cataract (Gilbert 2001).

Based on the WHO (2014a) figures for 2012, there are approximately 11.34 million children (< 15 years) in Mozambique. The prevalence of URE among children aged 4 - 15 years in Mozambique is unknown. Adopting the global URE prevalence reported by Reshnikoff et al. (2008) of approximately 1%, this could indicate that 20,160 children in Nampula and 108,864 children overall in Mozambique have VI due to a lack of spectacles. Applying the global rate of 1% to Mozambique should be observed with caution as it does not take into consideration that more visually impaired children live in poorer countries (Pascolini & Mariotti 2012, Gilbert & Muhit 2012).

Alternatively, loose comparisons may be made with African studies of similar age groups as a guide for estimating the magnitude of childhood URE in Nampula and Mozambique. Table 2.1 summarises the main URE prevalence studies in school children in Africa and
internationally. Loose estimates for prevalence of URE in Mozambique may be drawn from the most similar sample population aged 5 - 15 years in the Refractive Error in School Children (RESC), conducted in Durban, South Africa (Naidoo et al. 2003). In Durban the prevalence of VI from URE was 1.8% and the prevalence of VI from all causes including URE was 2.7%. If we consider that this prevalence data may be similar to Mozambique, this indicates that approximately 54,486 children in Nampula and 310,716 children in Mozambique are visually impaired due to a lack of spectacles.

A Rapid Assessment of Refractive Error (RARE) study (n = 3457) was conducted in Nampula in Mozambique in 2012 among adults aged 15 - 50 years (Loughman et al. 2014). In the RARE, participants’ vision was tested with a modified Illiterate E Snellen chart at 6 metres, failure to read the 6/12 line resulted in the use of a pinhole, reduction in test distance and potential referral for advanced refractive assessment (Loughman et al. 2014). The RARE methodology defined URE as VA < 6/12 improving to VA > 6/12 with pinhole. The RARE found the age and gender adjusted URE prevalence to be 2.6%, 95% CI [2.1% - 3.2%] (Loughman et al. 2014). In addition the RARE reported a 0% spectacle coverage rate. Ruiz – Alcocer et al. (2011) (n = 422) estimated the prevalence of RE in a group of university students in Maputo, Mozambique (17 - 26 years) to be 13% myopia and 4.8% hyperopia. The high prevalence of ametropia found by Ruiz – Alcocer et al. (2011) is in contrast to the low level estimated by (Loughman et al. 2014). This may be due to differing methodologies e.g. Ruiz – Alcocer et al. used non cycloplegic refraction techniques and examined a younger, urban population.
Table 2.1: Refractive error in children prevalence studies with refractive error categories

<table>
<thead>
<tr>
<th>Country</th>
<th>Test Type</th>
<th>Year</th>
<th>Sample Size</th>
<th>Age (years)</th>
<th>Myopia Category (Dioptries D)</th>
<th>Hyperopia Category (Dioptries D)</th>
<th>Astigmatism Category (Dioptries D)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nepal (rural)</td>
<td>2000</td>
<td>5067</td>
<td>5-15</td>
<td>1.2 CAR</td>
<td>2.1 CAR</td>
<td>3.5 CAR</td>
<td>Pokharel</td>
<td></td>
</tr>
<tr>
<td>Chile (urban)</td>
<td>2000</td>
<td>5303</td>
<td>5-15</td>
<td>7.3 CAR</td>
<td>19.3 CAR</td>
<td>27 CAR</td>
<td>Maul</td>
<td></td>
</tr>
<tr>
<td>China (semi-rural)</td>
<td>2000</td>
<td>4621</td>
<td>5-15</td>
<td>15.6</td>
<td>3.0 CAR</td>
<td>8.4 CAR</td>
<td>Zhao</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>2003</td>
<td>4890</td>
<td>5-15</td>
<td>4.0 CAR</td>
<td>2.6 CAR</td>
<td>6.8 CAR</td>
<td>Naidoo</td>
<td></td>
</tr>
<tr>
<td>China (urban)</td>
<td>2004</td>
<td>4364</td>
<td>5-15</td>
<td>38.1 CRet</td>
<td>4.6 CRet</td>
<td>42.7 CRet</td>
<td>He</td>
<td></td>
</tr>
<tr>
<td>India (urban)</td>
<td>2002</td>
<td>6447</td>
<td>5-15</td>
<td>7.4</td>
<td>7.7 CRet</td>
<td>7.7 CRet (non)</td>
<td>Murthy</td>
<td></td>
</tr>
<tr>
<td>India (rural)</td>
<td>2002</td>
<td>4074</td>
<td>7-15</td>
<td>4.1 CRet</td>
<td>0.78 CRet</td>
<td>3.8 CRet (non)</td>
<td>Dandona</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>2005</td>
<td>4634</td>
<td>7-15</td>
<td>19.3 CRet</td>
<td>1.3 CRet</td>
<td>15.7 CRet (non)</td>
<td>Goh</td>
<td></td>
</tr>
<tr>
<td>Kathmandu</td>
<td>2008</td>
<td>4282</td>
<td>10-15</td>
<td>10.9-27.3</td>
<td>0.34-1.21</td>
<td>7.9 CAR</td>
<td>Sapkota</td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td>2011</td>
<td>422</td>
<td>17-26</td>
<td>≤ 0.5D</td>
<td>≥ 0.5D</td>
<td>Power Vector</td>
<td>Ruiz-Alcocer</td>
<td></td>
</tr>
<tr>
<td>Ghana</td>
<td>2010</td>
<td>961</td>
<td>5-19</td>
<td>≤ 0.5D</td>
<td>≥ 0.5D</td>
<td>≤ 0.5D</td>
<td>Ovenseri-Ogbomo</td>
<td></td>
</tr>
<tr>
<td>Limpopo</td>
<td>2006</td>
<td>388</td>
<td>8-15</td>
<td>2.5</td>
<td>73.1</td>
<td>31.3</td>
<td>Mabaso</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>2013</td>
<td>4,238</td>
<td>7-18</td>
<td>≤ 0.5D</td>
<td>≥ 2.0D</td>
<td>≤ 0.50DC</td>
<td>Mehari</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>2003</td>
<td>535</td>
<td>4-12</td>
<td>≤ 0.5D</td>
<td>≥ 2.0D</td>
<td>≤ 0.50DC</td>
<td>Junghans</td>
<td></td>
</tr>
<tr>
<td>Iran</td>
<td>2007</td>
<td>5544</td>
<td>7-15</td>
<td>≤ 0.5D</td>
<td>≥ 2.0D</td>
<td>≥ 0.75DC</td>
<td>Fotouhi</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>2002</td>
<td>623</td>
<td>6-9</td>
<td>≤ 0.5D</td>
<td>≥ 0.5D</td>
<td>≤ 0.5D</td>
<td>Kawuma</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>2013</td>
<td>420</td>
<td>7.15</td>
<td>5.47</td>
<td>1.4</td>
<td>1.9</td>
<td>Sewunet</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>2014</td>
<td>142</td>
<td>6-10</td>
<td>≤ 0.5D</td>
<td>≥ 0.5D</td>
<td>≤ 0.5D</td>
<td>Mohamed</td>
<td></td>
</tr>
</tbody>
</table>

*All myopic and hyperopic categories use Spherical Equivalent (SE); (N)CAR - (non) cycloplegic autorefraction; NCR - non cycloplegic retinoscopy; CRet – cycloplegic retinoscopy; (*) - cycloplegic subjective refraction if VA ≥ 0.32 logMAR; ^ either eye; NCSR - non cycloplegic subjective refraction; CR - cycloplegic refraction; Power Vector - alternative mathematical representation of astigmatism.*
The conventional RE notation is [S (sphere), C (cylinder) X α (axis)]. The majority of research studies which statistically analyse RE, including the RESC studies, present their results in the spherical equivalent (SE) form. There is a lack of standardisation for the classification of RE among epidemiological research. A large number of papers on prevalence of RE in children use the definitions for RE outlined in the RESC studies as shown in Table 2.1 (Maul et al. 2000; Pokharel et al. 2000; Zhao et al. 2000; Dandona et al. 2002; Murthy et al. 2002; Naidoo et al. 2003; He et al. 2004; Goh et al. 2005). In addition Table 2.1 outlines other common classifications of RE.

Studies using NCR as a method of detecting URE are included in Table 2.1 as this is the method employed in study 1. Where two methods of refraction are used (RESC studies) the prevalence of ametropia varies. Table 2.1 displays a low prevalence of URE in African countries compared with a high prevalence in Asian countries. The study conducting in Egypt (North Africa) by Mohamed et al. 2014 reported exceptionally high prevalence of myopia in contrast to the sub Saharan African studies. Two thirds of the children examined in the Egypt study were from an urban area and watched television daily. This may indicate that these children had a higher socio economic status than the children of the other sub Saharan African studies.

A Rapid Assessment of Avoidable Blindness (RAAB) uses simple surveying techniques to estimate prevalence and causes of blindness in adults of 50 years and older (Kuper et al. 2006). The RAAB methodology differs to study 1 in that a chart with a Snellen Illiterate E size 18 on one side and a size 60 E on the other side is used. This chart is used
at 6 and 3 metres. Pinhole vision is checked if 6/18 is not seen in either eye (Kuper et al. 2006). The RAAB methodology defines URE as VA < 6/18 improving to VA > 6/18 with the pinhole.

A RAAB study (n = 3050) was conducted in Nampula in Mozambique in 2011 (Kimani 2011). The Nampula RAAB reported a prevalence of 7.1% blindness with an age and sex adjusted prevalence of 6.0%, 95% CI [4.7% - 7.3%]. The study also reported the age and sex adjusted prevalence of severe VI at 2.6 %, 95% CI [1.9%-3.3%] and VI at 6.0%, 95%, CI [5.0%-7.0%]. (The adjusted rate is a fabricated rate statistically modified to eliminate the effect of any variable, e.g. age or gender, which may have a different composition with respect to these variables to permit unbiased comparison between groups (Kasim 2012)). The Nampula RAAB reported URE to be the principal cause of moderate VI (43.5%) and the second leading cause of severe VI (15.6%) among adults over 50 years (Kimani 2011). The Sofala (province in central Mozambique) RAAB conducted in 2012 reported a prevalence of blindness of 3.2%, 95 % CI [2.6% - 3.8%]; and VI of 17.5%, 95% CI [16.3% - 18.9%] in adults over 50 years (Bedri 2014). Cataract caused 54% of blindness and 48% of VI. URE was the second most common cause of VI (48%) in Sofala (Bedri 2014).

Globally it is difficult to estimate the number of children who are blind or visually impaired because case detection is complex, the condition is relatively rare and requires large resources (Gogate et al. 2009).
Mozambique is one of the poorest countries in the world with children making up 45.4% of the population (World Bank 2014). Children in Mozambique have minimal access to eye care. The World Bank (2015a) listed an under five mortality rate of 103 per 1000 live births in 2011. In comparison the under five mortality rate in Ireland in 2014 was 4 deaths per 1000 (World Bank 2015a). According to Gogate & Gilbert (2007) the rate of childhood blindness in low income countries is approximately 1-1.2/1000 children, depending on the under-five mortality rate, or approximately 6,000 per 10 million of the population. Applying the Gogate & Gilbert method to Mozambique, roughly estimates there to be approximately

2820  (6,000 X 0.5 (based on a population of 4.7 million)) and

15,120  (6,000 X 2.5 (based on a population of 25.2 million)) blind children in Nampula and Mozambique respectively in 2011.

These are rough estimates and do not include the number of children with VI.

2.3 Other causes of vision impairment in children

Naidoo et al. (2014) list the main causes of blindness and VI for all ages in East Africa (which includes Mozambique) as cataract and URE respectively. Figure 2.1 gives a summary and percentage of blindness and moderate to severe VI as expressed by each cause.
Gilbert & Muhit (2012) explain that the causes of childhood blindness are dynamic over time, vary between regions and depend on the wealth of the country. Global childhood blindness aetiology data has, in many cases, been gathered from blind schools but it is estimated that only 10% of blind children are in blind schools (Gilbert 2001). Koay et al. (2014) explains that avoidable blindness is treatable or has preventable causes, whereas unavoidable blindness is due to hereditary or congenital disorders. 50% of childhood blindness cases are avoidable (Gilbert et al. 2003); some require primary level interventions and others tertiary services (see Section 2.4). Parikshit & Gilbert (2007) review of the causes of childhood blindness indicate that in the poorest countries these
are corneal scarring, cataract, glaucoma and optic atrophy. Other eye diseases, systemic conditions and environmental factors can also cause poor CEH (Gilbert 2001). Naidoo et al. (2003) stated that the main causes of VI in the Durban RESC study after URE are amblyopia, cataract and retinal causes.

### 2.4 Primary eye care in the national health care model

The WHO (1978) Declaration of Alma Ata describes primary health care as a global term that includes primary care and every aspect of health care in the community including socioeconomic considerations. Community based health care is described by Mburu & Boerma (1989) as taking primary health care into the participating community, for the benefit of the community. This thesis examined several aspects of primary and community care.

In its simplest form, a national eye health model consists of primary, secondary and tertiary care. The majority of treatable causes of VI and ocular pathology can be treated in the community and primary eye care centres. Secondary care or hospital ophthalmology departments treat conditions such as cataract and glaucoma which require surgical intervention. Conditions which cannot be treated at community and primary level should be referred for treatment at service centres in provincial hospitals. It is expected that only a very small percentage of the population will suffer from more serious and complex eye conditions which require treatment at the tertiary level. Tertiary eye care facilities are centres for advanced surgeries e.g. retinal surgery. Figure 2.2 demonstrates the basic hierarchical concept of a national eye care system.
The International Agency for the Prevention of Blindness (2009) suggests that no “one shoe fits all” when it comes to primary eye care. Lakshmi Vara Prasad Eye Institute (2013) emphasised the importance of “vision guardians” to community and primary care. Vision guardians (case finders) find children in the community who have VI and refer them to vision centres. The second study in Chapter six investigated the potential role of teachers as case finders/vision screeners in Nampula. It assessed their accuracy as vision screeners and investigated the potential barriers to teacher vision screening and case finding in the community. According to Etya'ale (2011) a fully functional primary eye care service should have accessible services e.g. eye examinations and affordable treatment e.g. spectacles. Etya'ale (2011) stressed the importance of linking children in communities to paediatric services, including public education on the availability of
services and the nature of common ocular conditions. In relation to advocacy or primary eye care Etya'ale (2011) states potential stakeholders should be empowered and longstanding active partnership encouraged. Chapter six identified stakeholders, partnerships and activities at primary care level which have potential to include CEH.

The WHO (2013) resolution “Universal eye health: a global action plan, 2014 - 2019” has, as its second objective, to improve universal eye health through comprehensive eye care services integrated in strengthened health systems. Mills (2005) explains that selective approaches are mainly organised and implemented by a team of health workers dedicated to provision of health care for one condition only e.g. URE screening. The WHO resolution indicates the movement of International Agency for the Prevention of Blindness and eye health stakeholders away from the traditional view of eye health as a selective strategy and towards a more comprehensive approach. Gonzalez (1965) as cited by Mills (2005) suggests that selective health systems are useful in addition to, but not instead of, comprehensive health systems. Chapter three identified broad health strategies in Mozambique where integration of CEH could be considered.

It is well documented in the grey literature that school health programmes must be led by the departments of health and education with interdepartmental cooperation, community stakeholder engagement and partnership (United Nations Educational, Scientific and Cultural Organization (UNESCO) 2014, WHO 1997, WHO 2006). Gilbert (2014) stipulated that School Eye Health Programmes should not be standalone activities that only deal with URE but should also aim to treat other eye diseases. Sightsavers
International (2011) also stated that School Eye Health Programmes ought to be comprehensive, aligned with international child health initiatives and integrated into school health initiatives. Internationally there is a strong move towards comprehensive school eye health programmes (Yasmin et al. 2015). Belli et al. (2005) stated that investing in children’s health not only has economic benefits but also improves enrolment, performance and progression to secondary education. The Ministry of Education - Education Plan (2012) stated that a healthy and safe school environment required partnership with families, communities, governmental and non-governmental organisations. Therefore, improvements to school health and hence CEH should be Ministry of Health and Ministry of Education led.

This thesis looks in particular at school eye health initiatives as a component of primary care in Mozambique and Ireland. Key aspects of school eye health outlined by the International Agency for the Prevention of Blindness (2009) undertaken in this thesis include:

- Case detection and spectacle coverage.
- Identification and referral of common eye complaints of children.

School Eye Health Programmes have the potential to encourage community empowerment. According to WHO (2014b) community empowerment is a method of supporting communities in attainment of control over their lives. Mashalla-Kema et al.
(2012) outline the main benefit of community empowerment as the stimulus to continue solving community problems after the initial issues are resolved.

2.5 Conclusion

No studies have been published on the prevalence and causes of childhood VI and URE in Mozambique. This chapter has provided an estimate of the amount of VI and URE likely to be present among children in Mozambique. It outlined the main causes of VI in developing countries. As this thesis is primarily concerned with primary CEH and school vision screenings, the context of these has been discussed in terms of the broader generic national CEH model. The following two chapters introduce Mozambique and Ireland geographically and in the context of their CEH plans and policies.
3 CHAPTER THREE: AN INTRODUCTION TO MOZAMBIQUE

3.1 Mozambique

The Republic of Mozambique (hereafter referred to as Mozambique) lies on the southerly tip of the east coast of Africa as shown in Figure 2.1. It is divided into 11 provinces including the capital Maputo, 128 districts and 53 municipalities. Nampula province, where this study was based, highlighted in red in Figure 2.2 is a rural but densely populated province located in North Mozambique.

Figure 3.1: Global Map

Mozambique is highlighted in green, Ireland is highlighted in red. Source: Kable (2015)
Mozambique is a low income country in sub-Saharan Africa with a population of 25.8 million (World Bank 2013a). In 2012, approximately 45.4% of the population were children under 15 years of age (WHO 2014a). Portuguese, the official language of Mozambique is spoken by 10.7% of the population. There are several indigenous
languages to Mozambique, including Makua which is spoken in Nampula and by 25.3% of the national population (Central Intelligence Agency 2014).

Mozambique attained independence from Portugal in 1975. The civil war (1977-1992), drought and mass emigration of middle class following independence damaged the country. Mozambique is the world’s third poorest country (United Nations Development Programme 2014) but has a rapidly growing economy and is resource rich in minerals with very fertile lands (Central Intelligence Agency 2015). In 2008 approximately 82.0% of the population lived on less than $2 a day (World Bank 2014). Approximately 57.0% live in poverty (World Bank 2014). Thompson (2014a) reported that in 2013 the mean cost of spectacles among 76 spectacle wearers in Nampula was $21.3 (range $0 to $264). Infrastructure in Mozambique is poorly developed. The majority of Mozambicans work the land and live in the countryside in improvised housing units (huts, cabins, shanties).

3.1.1 Nampula

Nampula province is divided up into 18 districts and 5 municipalities. The population in 2013 was approximately 4.7 million of which 45.4% were children under 15 years old (WHO 2014a). The provincial capital Nampula city is the largest town in Northern Mozambique. Life expectancy in Nampula in 2007 was 52.9 years which is slightly higher than the national average of 49.4 years (National Institute of Statistics 2007). In 2007, the adult literacy rate was 37.7% for over 15 years old (males 53.5% and females 22.6%). This was below the national average 49.4% (National Institute of Statistics
Although more recent figures for Nampula are not available, according to the 2007 census, the literacy rate in Nampula had risen consistently in the years preceding 2007.

3.2 Government of Mozambique ministries influencing child eye health

CEH in Nampula is influenced by the Ministry of Health and Ministry of Education. This section gives a context and background to study 1 and 2. It outlines the current situation in Nampula regarding human resources and infrastructure for these two ministries.

In 2012, primary education in Nampula included day and evening school shifts with a first level of primary school (1st to 5th grade), a second level of primary school 2 (6th and 7th grade) and some schools offer all the grades (1st to 7th grade) (Ministry of Education 2013a) see Figure 3.3.

**Figure 3.3: Primary School Structure in Mozambique**

- **Pre-School Education**
  - Optional although not widely available

- **First level of Primary Education (EP1)**
  - Grade 1-5
  - Official enrolment is at six years of age.
  - Primary school education is compulsory and free throughout Mozambique

- **Second level of Primary Education (EP2)**
  - Grade 6-7

*Two levels of primary school: first level (age 6 – 10 years); 2nd level (age 11-12 years).*
There are a large number of students and schools in Nampula city and province as shown in Table 3.1. The pupil teacher ratio is very high but is lower in the city compared with the province as demonstrated in Table 3.1. This indicates that more teachers are working in the city.

Table 3.1: Number of primary schools, students and teachers in Nampula in 2012

<table>
<thead>
<tr>
<th></th>
<th>Number of Primary Schools (1st &amp; 2nd Level)</th>
<th>Number of Children</th>
<th>Number of Teachers</th>
<th>Pupil Teacher Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nampula City and District</td>
<td>303</td>
<td>179,159</td>
<td>3867 (54% female)</td>
<td>46:1</td>
</tr>
<tr>
<td>Total Nampula Province</td>
<td>2769</td>
<td>960,637</td>
<td>15,951 (32% female)</td>
<td>60:1</td>
</tr>
</tbody>
</table>

There were almost 1 million children attending primary school in 2012 in Nampula. Children in the city benefit from lower pupil teacher ratios and more female teachers. Source: Ministry of Education (2013a).

To accommodate the large number of children attending school there were multiple sessions in a day depending on the size of the school. In 2010 the pupil teacher ratio reported by the principals of three schools visited in study 1 and study 2 was on par with the national average at 58:1 (range 47-76:1) (World Bank 2015b). Interestingly this national figure had reduced to 55 in 2014 (World Bank 2015b), which demonstrates that government initiatives to reduce the pupil teacher ratio are working.
The Ministry of Health is a key stakeholder in CEH. The health system is 60% public sector, with other health services provided by for profit and not for profit private organisations. The public health system is based on primary health care principles (WHO 2008), discussed in more detail in Section 2.4. A situational analysis of eye care services in Mozambique (MECC 2012) revealed that there are 30 hospitals that provide eyecare outside of Maputo city and province (data not available for Maputo).

The Government of Mozambique Multisectoral Action Plan for Chronic Malnutrition, 2011, stated that Nampula had one health clinic per 10,000 to 15,000 inhabitants (Government of Mozambique 2010). Primary eye care is provided by Nampula Central Hospital (along with secondary eye care) and the optometry teaching clinic in University of Lúrio. Latorre - Arteaga (2015, personal communication) suggested that there were four private optical shops, three public primary care clinics in Nampula city and five public clinics in the province.

The VISION2020 initiative aims at one midlevel eye care worker for 50,000 people and one ophthalmologist for 250,000 people by 2020 (VISION2020 2007). The number of optometrists required is not specified in this document. According to the International Agency for the Prevention of Blindness (2015) in 2014 there were 21 ophthalmologists and 130 ophthalmic technicians in Mozambique. There were eight ophthalmic technicians and two ophthalmologists working in Nampula province in 2011 (Shah 2015c). This is far less that the VISION2020 (2007) population adjusted target of 94 ophthalmic technicians and 19 ophthalmologists for Nampula by 2020.
Sanchez Seco (2015, personal communication) stated that there were 29 optometrists working in education, the public and private sector in Mozambique in 2015. A four year optometry degree programme was established in University of Lúrio, Nampula in 2009 through The Mozambique Eyecare Project collaboration. The majority of the recent graduates are employed by the Ministry of Health in various ophthalmology departments throughout Mozambique. According to Sanchez Seco there are two hospital optometrists working in Nampula Central Hospital (2015b, personal communication). According to the collaborators of the Mozambique Eyecare Project, the University of Lúrio programme includes a public optometry clinic, with a spectacle glazing lab and incorporates clinical and epidemiological research (Mozambique Eyecare Project 2013, University of Lúrio 2013).

Shah (2015a) assessed the competencies, training and up-skilling of a sample of Mozambique’s ophthalmic technicians. The skill level of these ophthalmic technicians varied with some more capable of refraction and retinoscopy than others (Shah 2015a). Additional refraction training for ophthalmic technicians, of a minimum duration of 2 weeks, was recommended following analysis of the study findings. Shah (2015b, personal communication) indicated that the ophthalmic technician curriculum in is under review and a Mozambican Optometrist is on the review committee. This extra refraction training has been implemented for two cohorts of trainee ophthalmic technicians on the Ministry of Health led course in Beira in Mozambique in 2011.
There have been several important developments in eye health care in Nampula over the past five years including a strong eyecare NGDO presence, the establishment of the University of Lúrio optometry course and clinic and the building of the new ophthalmological wing at Nampula Central Hospital. Although infrastructure and human resources are gradually increasing, there are limitations to primary eye care in Nampula and the rest of Mozambique. These limitations or deficiencies indicate that children in Nampula with poor eye health are most likely not receiving treatment.

3.3 Government of Mozambique plans and partnerships influencing child eye health

3.3.1 Government of Mozambique plans

There is currently no dedicated National Ophthalmology Plan being implemented in Mozambique although there is a plan in draft stage (Thompson 2014a). A section in the previous National Eyecare Plan (2007-2010), entitled the Child Eye Health Programme specified that vision screening charts should be dispensed to schools (Garrido 2007). There was very little information on this programme given in the plan. No evidence of this activity (dispensing vision charts) could be gathered. At the national eyecare planning meeting in Maputo, in 2011, presentations from ophthalmic technicians suggested that currently only sporadic school vision screening is conducted, and these employ differing protocols due to the lack of any standard protocol or system. The researcher took notes at these presentations, however no reference or copy of the presentations are available. A situational analysis of eye care services in Mozambique
(Mozambique Eye Care Coalition 2012) revealed that 21 school vision screening activities took place in Mozambique, outside of Maputo, in 2011, 5 of which took place in Nampula.

Primary eye care was integrated into broader health plans as evident from the National Social and Economic Plan for 2013-2014 (Government of Mozambique 2013). The Government of Mozambique has medium term overarching governmental development plans along with short term national and provincial plans (WHO 2014c) which will influence CEH, see Table 3.2. It is interesting to note the reduction in the number of vision screenings planned from 2013 to 2014 in the National and Social Economic Plan.
Table 3.2: Example of government policies which may influence child eye health services in Nampula

<table>
<thead>
<tr>
<th>Government Plan</th>
<th>Length /Term</th>
<th>Relevance to Child Eye Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mozambique Poverty Reduction Action Plan 2011-2014</td>
<td>Medium (3/4 years)</td>
<td>Overarching governmental development plan which guide the plans below. Prioritises decentralisation &amp; capacity building for local administrations and consolidating municipalities</td>
</tr>
<tr>
<td>The Human Resources for Health Plan (2011-2015)</td>
<td>Medium (4/5 years)</td>
<td>The human resources for health plan has as its objectives to reduce the human resources deficit, retain the health workforce and increase the Ministry of Health capacity to train. These objectives are strongly link to eye health provision in the country.</td>
</tr>
<tr>
<td>National Social and Economic Plan (PES) 2013-2014</td>
<td>Short (1 year)</td>
<td>Includes a section on ophthalmology in the health section which does include CEH in addition to a trachoma plan.</td>
</tr>
<tr>
<td>National Social, Economic and Plan 2013-2014</td>
<td>Short (1 year)</td>
<td>The 2014 plan prioritises screening for eye problems in a total of 22 schools - 2 schools per province. It states the importance of child health in school and notes that there is a poor infrastructure in many schools.</td>
</tr>
<tr>
<td>National Social, Economic and Plan 2012-2013</td>
<td>Short (1 year)</td>
<td>The 2013 plan prioritised URE solely vision screenings in a total of 256 schools - 2 schools per district, nationally.</td>
</tr>
</tbody>
</table>
National Plans relating to CEH with timeframes

3.3.2 Government of Mozambique partnerships

3.3.2.1 Mozambique Eye Care Coalition

The Mozambique Eye Care Coalition is an umbrella group of eye care NGDOs and Ministry of Health who exercise a collaborative approach to eye care initiatives such as trachoma mapping and elimination, human resources for eye health training and the development of the National Eye Care Plan. The Mozambique Eye Care Coalition NGDO partners work closely with the National Eyecare Coordinator, an ophthalmologist appointed by the government, to improve eye health in Mozambique. See Appendix 3.1 for a list of members of the Mozambique Eye Care Coalition. Nationally, several eyecare NGDO partners in the Mozambique Eye Care Coalition are involved in projects which provide CEH services. The Mozambique Eye Care Coalition members do report their activities yearly but there is no specific section on the report dedicated to child eye care. Mozambique Eye Care Coalition members were asked to summarise their paediatric eye care activities in Mozambique in 2011. Activities reported included ‘some school screening’, ‘> 7000 children screened with 80 teachers trained in vision screening’, one
ophthalmologist performed approximately 30 paediatric cataract operations, another
performed 15 cataract operations; trachoma mapping; vitamin A supplementation. In
2013, the NGDO who had trained the teachers reported that vision screening had stopped
due to the optical workshop not functioning.

3.3.2.2 The Mozambique Eyecare Project

Study 1 and study 2 were carried out as part of the Mozambique Eyecare Project. This
project was a cross institutional, multinational collaboration involving Irish Aid, the
Dublin Institute of Technology, the University of Lúrio, (Mozambique), the Brien Holden
Vision Institute and the University of Ulster. The project was funded through the Irish
Aid/Higher Education Authority Programme of Strategic Cooperation, it was also part
funded by the Dublin Institute of Technology, the Brien Holden Vision Institute and the
University of Lúrio. The partners established Mozambique’s first optometry degree
programme in the University of Lúrio, Nampula, Mozambique. The Mozambique
Eyecare Project has undertaken several research studies including a Rapid Assessment of
Refractive Error (RARE) in Nampula city and district, several PhD studies (Shah 2015c,
Thompson 2014a) and supported a baseline survey of public health systems in
Mozambique (Thompson 2014a). The partners supported refraction training for
ophthalmic technicians and national eyecare advocacy and planning through the
Mozambique Eye Care Coalition.
3.4 Conclusion

This chapter provides background information on Mozambique, its government departments, plans, policies and partnerships which are relevant to CEH. It is clear there is a dearth of health care provision in Mozambique. In addition primary education has major resourcing challenges. The next chapter reviews the current available literature on the prevalence of VI and URE in Northern Ireland and the prevalence of blindness in the Republic of Ireland. It also outlines the paediatric eye health care scheme in the Republic of Ireland.
CHAPTER FOUR: CHILD EYE HEALTH IN IRELAND

4.1 Introduction

This chapter introduces the Republic of Ireland (hereafter referred to as Ireland). It reviews the available literature on the prevalence of VI and URE and the causes of blindness in Ireland. In addition the CEH care model in Ireland is outlined and discussed.

Ireland is a small developed country, consisting of 26 counties, on the west coast of Europe. According to the Central Statistics Office (2015) the population of Ireland was 4.6 million people. Children aged 0 - 14 years make up over one fifth (22.20%) of the population of Ireland. Life expectancy is 79 years for men and 83 years for women (Organization for Economic Cooperation and Development 2015). According to the 2011 Irish census 42,387 people aged over 15 years had no formal education (Government of Ireland, 2012). In 2013 the pupil teacher ratio in primary schools was 16.4:1 (Department of Education 2014).

4.2 Estimating the prevalence of refractive error and visual impairment in Irish children

The recent Northern Irish epidemiological study conducted in by O’ Donoghue et al. (2010) estimated RE prevalence in 6 - 7 year old Caucasian children to be myopia 2.8%, 95% CI [1.3% - 4.3%] and hyperopia 26%, 95% CI [20 - 33]. They estimated RE prevalence in 12 - 13 year old Caucasian children to be myopia 17.7%, 95% CI [13.2% -
22.2%) and hyperopia 14.7%, 95% CI [9.9% - 19.4]. O’Donoghue et al. stated VI (> 0.30 logMAR or 6/12) prevalence as 1.5%, 3.6% in the younger and older age groups respectively.

Three years later O’Donoghue et al. (2015) conducted a prospective study on these children and concluded that the prevalence rate for astigmatism (≥ 1.00DC) did not vary in the 2 cohorts. Interestingly, although the prevalence remained unchanged, the same children were not necessarily astigmatic on the second refraction. O’Donoghue et al. (2015) concluded that there was a change in the profile of astigmatism in the Northern Irish children.

The recent study commissioned by the National Council for the Blind of Ireland (2011) estimated the prevalence of blindness, mild VI, and moderate VI at 0.3%, 14.8%, and 4.7% respectively for children younger than 19 years of age. Tables 4.1, 4.2 and 4.3 were adapted from that report to give a breakdown of the estimates based on gender and age for each level of impairment.
### Table 4.1: Prevalence rates for blindness in children in Ireland

<table>
<thead>
<tr>
<th>Age group</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>0.03%</td>
<td>0.03%</td>
<td>0.03%</td>
</tr>
<tr>
<td>5 - 9</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.05%</td>
</tr>
<tr>
<td>10 - 14</td>
<td>0.10%</td>
<td>0.09%</td>
<td>0.09%</td>
</tr>
<tr>
<td>15 - 19</td>
<td>0.10%</td>
<td>0.09%</td>
<td>0.10%</td>
</tr>
<tr>
<td>Total</td>
<td>0.27%</td>
<td>0.25%</td>
<td>0.26%</td>
</tr>
</tbody>
</table>

(a) Blindness defined as VA < 6/60 (>1.0 LogMAR) in better eye or central visual field ≤ 20 degrees. (b) Total people on NCBI register in 2010 adjusted upwards by 1.3 adjustment factor to account for under-registration (Kelliher et al. 2006). Source: National Council for the Blind of Ireland (2011).

### Table 4.2: Prevalence rates for mild vision impairment in children in Ireland

<table>
<thead>
<tr>
<th>Age group</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>1.40%</td>
<td>1.80%</td>
<td>1.60%</td>
</tr>
<tr>
<td>5 - 9</td>
<td>2.80%</td>
<td>2.50%</td>
<td>2.70%</td>
</tr>
<tr>
<td>10 - 14</td>
<td>5.40%</td>
<td>4.80%</td>
<td>5.10%</td>
</tr>
<tr>
<td>15 - 19</td>
<td>5.60%</td>
<td>5.10%</td>
<td>5.40%</td>
</tr>
<tr>
<td>Total</td>
<td>15.20%</td>
<td>14.20%</td>
<td>14.80%</td>
</tr>
</tbody>
</table>

Mild vision impairment defined as 6/18 ≤ VA < 6/12 (0.5 ≤ LogMAR VA ≥ 0.3). Source: National Council for the Blind of Ireland (2011).
Table 4.3: Prevalence rates for moderate vision impairment in children in Ireland

<table>
<thead>
<tr>
<th>Age group</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>0.50%</td>
<td>0.60%</td>
<td>0.50%</td>
</tr>
<tr>
<td>5 - 9</td>
<td>0.90%</td>
<td>0.80%</td>
<td>0.90%</td>
</tr>
<tr>
<td>10 - 14</td>
<td>1.70%</td>
<td>1.60%</td>
<td>1.60%</td>
</tr>
<tr>
<td>15 - 19</td>
<td>1.80%</td>
<td>1.70%</td>
<td>1.70%</td>
</tr>
<tr>
<td>Total</td>
<td>4.90%</td>
<td>4.70%</td>
<td>4.70%</td>
</tr>
</tbody>
</table>

Moderate vision impairment defined as \(6/60 \leq VA < 6/18\) \((1.0 \leq \text{LogMAR VA} \geq 0.5)\).


To date no study has been published on the prevalence of URE among children from Ireland. However Bourne et al. (2014) concluded that URE is responsible for 14%, 95% CI [8.4% – 18.1%] of blindness (presenting VA < 3/60) and 47.3%, 95% CI [38.5% – 53.7%] of moderate and severe vision impairment (presenting VA < 6/18 but \(\geq 3/60\)) for all ages (0 – 90+ years) in Western Europe in 2010 as shown in Figure 4.1.

Donnelly et al. (2005) conducted a review (n = 1582) of the strabismus and RE present among children (aged 8 - 9 years) living in Northern Ireland (Newry and Mourne Trust catchment area). This study found a prevalence of RE of 8.2% this consisted of 1.4% myopia \((\leq -0.75\text{D})\), 3.4% hyperopia \((\geq +1.50\text{D})\) and 3.4% astigmatism \((\geq 1.00\text{D})\).

Donnelly et al. (2005) reported 53 cases of esotropia and 10 cases of exotropia. There were 6 (0.4%) cases of organic defects (e.g. optic atrophy).
Figure 4.1: Proportion of blind and moderate to severe vision impairment in Western Europe (0 – 90+ years)

Blindness (presenting visual acuity < 3/60); Moderate and severe vision impairment (presenting visual acuity < 6/18 but ≥ 3/60). Source: Bourne et al. (2014).

4.3 Estimating non refractive causes of vision impairment in Ireland

The National Council for the Blind of Ireland (2011) gave an estimate of the causes of blindness in children but unfortunately since it was based on the register for the blind where the only options are cataract, AMD, diabetic retinopathy or glaucoma or other, most of the cases of childhood blindness are reported as other. For instance it attributed cataract as the cause of 0.005% of childhood blindness, glaucoma as 0.001% and AMD as 0.001%. The case of AMD in a young child may have been miscategorised and is more likely to be juvenile macular degeneration.
Khan et al. (2007) used data from all the ophthalmology departments and the National Council for the Blind to classify the causes of childhood blindness in children under 18 years of age in the Republic of Ireland. The 384 children with blindness (0.1% of the population) were grouped into four broad categories – genetic (33% of cases), prenatal (27% of cases), perinatal (26% of cases) and retinal dystrophies (12.4% of cases). The leading causes of blindness were albinism (15.6%), cortical blindness (17.5%) optic nerve hypoplasia (8.6%), structural anomaly (7.3%), retinopathy of prematurity (5.5%) and cataract (5.5%). Of note, there was a reduction in the amount of blindness due to retinopathy of prematurity compared to that reported in a study by Goggin and O’Keefe (1998); this is most likely due to early diagnosis and treatment. Another study was conducted by Flanagan et al. (2003) on children under 19 years of age in South and East Belfast, Northern Ireland, the authors found the main causes of blindness (n = 76) to be cortical VI (45%), congenital nystagmus (8%), oculocutaneous albinism (8%), congenital cataracts (8%), micorophthalmia (5%), retinopathy of prematurity and retinitis pigmentosa (5%). Comparison between the studies by Khan et al. (2007) and Flanagan et al. (2003) is difficult due to the diverse target populations, different methods of data capture and dissimilar categorisation of ocular pathology.

4.4 Primary child eye health care in Ireland

The HSE is the public health service provider for Ireland. It has responsibility for provision of all public health services from primary care (see Figure 4.2 for map of clinics) to tertiary care (see Figure 4.3 for map of hospitals). There are 48 public hospitals
and over 500 health centres in Ireland (HSE 2015a). Nine community healthcare organisations are to be introduced in Ireland as part of an integrated primary care service reform (HSE 2014).

**Figure 4.2: Map of Ireland with HSE centres identified.**

**Figure 4.3 Map of Ireland with health hospitals identified.**

Eye health and vision screening in Ireland is carried out regularly by non eyecare health professionals from birth to nine months. In public primary schools two additional checks are performed at entrance (age 4 – 6 years) and exit (age 11 – 13 years) by the HSE (Government of Ireland 2005). These vision screenings (hereafter referred to as HSE school screening) are performed by ophthalmic public health nurses (hereafter referred to as nurses) as part of the community ophthalmic scheme.
The “Best Health for Children Revisited” document published by the Irish Government (2005) outlines vision screening personnel, rationale and referral criteria for CEH. It recommends that VA be measured by a nurse using logMAR crowded 3 metres test, illuminated Snellen Acuity test at 6 metres or Sonksen Silver VA matching test. The referral criteria for primary school children are unaided VA of 6/9 (0.2 logMAR / 1.6 MAR) or difference in VA between the two eyes of more than one line. Anecdotal evidence suggests that nurses record the unaided vision or aided visual acuity if applicable in triplicate. A copy of the results is sent to the parents, the nurse will usually contact the parents to explain the results and explain the referral pathway and waiting times.

The Health Act 1970, Section 67, (Government of Ireland 1970) states that the HSE must provide ophthalmic treatment and appliances in respect of defects discovered at school by nurses. Critically the nurse refers children who fail the vision screening to the primary care clinic where they are put on a waiting list to attend the community ophthalmic physician.

In some areas of Ireland children are on a waiting list of 6 weeks to 2 years for an eye examination with the community ophthalmic physician (Bray 2014). According to the National Treatment Purchase Fund (2015) the number of children on the waiting list for outpatient ophthalmology procedures in July 2015, in the three national children’s
hospitals was 1749 (Children’s University Hospital Temple Street), 1010 (Our Lady’s Children’s Hospital Crumlin), 98 Tallaght Children’s Hospital). In May 2015 the Irish Medical Independent reported that approximately 70% of children on the waiting list in Temple Street could be treated in a primary care setting (Lynch 2015). The Primary Care Division Operational Plan (HSE 2015b) introduced new metrics to capture data on waiting lists for ophthalmic services in the HSE.

In 2012 there were 22 community ophthalmic physicians employed by the HSE (Irish Medical Organisation 2012). These physicians refract children, there are no community optometrists in Ireland. There are currently 40 full and part time orthoptists working in Ireland in the public and private sector (Irish Association of Orthoptists 2015). There is currently no HSE orthoptic service in counties Clare, Carlow, Wicklow, Mayo and Louth.

Of note, the HSE Community Ophthalmic Services Scheme is a contract with eye care professionals in which adult and teenage (12 - 16yrs) medical cardholders are entitled to eye examinations and necessary spectacles free of charge (HSE 2006). No HSE contract or legislation exists to allow optometrists to claim for children’s eye examinations and therefore parents must pay for private paediatric eye examinations conducted by optometrists. The HSE local health offices process appliance only claims for children’s spectacles (HSE 2006). It is at the discretion of the local office as to whether or not they issue a spectacle voucher to a parent with an optometrist’s prescription. A review of the HSE primary care services is currently underway, a final report is due at the end of 2015.
(Lynch 2015). Loughman (2015, personal communication) identified a proposed plan by the HSE to employ optometrists directly in order to reduce the waiting times.

Many parents opt for private child eye care as an alternative to the public system. They may choose to have their children’s eye health assessed by an ophthalmologist or an optometrist. In 2015 there were 24 paediatric ophthalmologists listed on the Irish College of Ophthalmologists website (2015). There were other ophthalmologists who may have a special interest in paediatric ophthalmology but who may not be registered on that page. Optometrists in Ireland must be registered with the Opticians board and in general they have trained in Ireland or the United Kingdom. In 2014 there were 754 optometrists registered in Ireland (Irish Optician’s Board 2015). There were approximately 368 private optometry practices in Ireland (What Clinic 2015). Currently optometrists are regulated through the Opticians Act 1956 (Government of Ireland 1956). In the coming months the Opticians Act 1956 will be repealed and the profession will become regulated by the newly established Health and Social Care Professionals Act 2005 (Government of Ireland 2012b). The change in regulation will potentially increase the optometrist’s scope of practice. The future professional code of conduct states that optometrists should work within their competence and experience, whereas the previous Act limited the scope of practice.
4.5 Conclusion

There is a well-established care pathway for children with VI and URE in Ireland. In addition there is the option of private primary eye care either through an optometrist, ophthalmic physician, ophthalmic consultant or orthoptist. In the public system there are issues surrounding the waiting lists for children failing the HSE school screening. The following chapter investigates the outcomes of the first optometry led school vision screenings of school children in Nampula, Mozambique.
5 CHAPTER FIVE: STUDY ONE: OUTCOMES OF EYE HEALTH ASSESSMENT IN FIRST SCHOOL SCREENINGS BY OPTOMETRISTS IN MOZAMBIQUE

Abstract

Purpose:
In 2010 and 2012 children from three schools (one urban, one semi urban and one rural), were screened for VI, URE and presence of ocular abnormality.

Methods:
Children failed the vision screening test if monocular VA was $\geq 0.32$ logMAR ($< 6/12$). The right eye SE value detected by NCR was used for analysis of the URE. Data were categorised for myopia and hyperopia (SE $\leq -1.00$D and $> +1.50$D) and astigmatism (cylinder $\leq -0.75$D). Spectacle coverage was assessed.

Results:
749 children aged 4 - 18 years completed the study. The mean RE was $+0.77 \pm 0.93$ (SD). There were 18 (2.4%, 95% CI [1.3% - 3.5%]) myopes, 49 (6.5%, 95% CI [6.2% - 6.7%]) hyperopes and 48 (6.4%, 95% CI [4.7% - 8.1%]) cases of astigmatism. The spectacle coverage was 0%. Ocular abnormalities were present in 12%, 95% CI [9.7% - 14.3%] of children.

Conclusion:
The NCR results revealed that the children were mainly emmetropic. School children in need of correction did not have spectacles. The 12% rate of ocular abnormality indicates that there are several public health issues which need to be addressed in Nampula.
5.1 Introduction

Currently there is no established school vision screening programme in Nampula where children have very limited access to eye health services. Ophthalmic technicians, with varying levels of confidence and competence at retinoscopy and refraction (Shah 2015a) work in the hospital and public clinics, they also conduct school vision screenings as discussed in Section 3.2. This study implemented a school eye health screening in Nampula to assess the vision and eye health of children attending primary school. The study also assessed the feasibility of optometry led school eye health screening in Nampula. This was the first ever school eye health screening by optometrists in Nampula, Mozambique. This study also investigated the number of children who presented at the school screening wearing spectacles.

5.1.1 Aims and Objectives

The specific aims and objectives for the research were:

1. To set up the first optometry led school CEH screening in Nampula and evaluate the outcome.

2. To apply international classifications for URE to the NCR results of this study to estimate the amount of URE using NCR results among this targeted cohort of school children.

3. To assess the spectacle coverage rate.
5.2 Materials and methods

5.2.1 Setting and participants

The study took place in three primary schools, one each in an urban (4000 pupils), semi-urban (5241 pupils) and rural (1914 pupils) location (2010 total school population figures) in Nampula, Mozambique, over six days in September 2010 and March 2012. A total of 763 children were examined from the three primary schools, 205, 274 and 270 children from urban, semi urban and rural schools respectively. Due to missing information on the records of 14 children, the data from 749 children was used. The number of children who underwent the vision screening in 2010 and 2012 was 313 and 436 respectively.

Inclusion criteria

Children aged 4 - 18 years of age in each of the three schools visited could take part in the screening.

Priority for screening

The initial aim was to prioritise children aged 5 - 7 and 11 - 12 years for vision screening. However due to the large number of children in each school and the lack of resources, children with obvious eye abnormalities or children identified by teachers or the research team as having an eye problem/poor vision underwent vision screening (approximately one third of subjects). An optometrist would visit the classroom, observe children for
obvious ocular abnormality and ask the teacher if he/she could identify any child with a vision or eye problem. Additionally a random selection of children who queued at the classroom door or were released as a class by a teacher to attend also underwent vision screening (approximately two thirds of subjects).

**Figure 5.2.1: Child vision and eye health screening in urban primary school**

One classroom was kindly allocated to the team by the school principal in each school. Children are wearing blue shirts. Eye research team are wearing white. Children seen looking in the windows are queueing for the screening. Photo courtesy of Benjamin Drummond, bdsjs.com.

**Exclusion criteria**

Adults > 18 years were not included in the study.
5.2.2 Vision screening personnel

Vision screening was conducted in school classrooms by a clinical team consisting of five optometrists and fifteen student optometrists on each visit. The student group included final year Irish optometry students and second and third year Mozambican optometry students. The study team were proficient in all the study techniques in advance of the screening. On the first day of screening the study protocol, including equipment use, measurement methods, and correct completion of data collection forms (shown in Appendix 5.1) was outlined by the principal investigator (Aoife Phelan (A.P.)).

In 2010 all measurements including cover test (distance and near) were conducted by seven senior optometrists. In 2012 the student optometrists carried out the vision screening (University of Lúrio second and third year students (n = 8)) and ophthalmoscopy (DIT year four students (n = 3)) alongside and under the supervision of qualified optometrists (n = 6). Any suspected pathology was checked and confirmed by an optometrist. Cover test was conducted only on children with obvious ocular deviation. NCR was carried out by two senior optometrists on each visit (four in total).

5.2.3 Vision screening procedures and instruments

Each child underwent the following screening protocol: Distance VA (child was asked to look at a letter chart with one eye covered alternately), NCR (objective measure of approximate spectacle prescription) conducted at 67cm, external ocular health assessment and ophthalmoscopy.
Several different chart types were employed: Letter or illiterate E chart, Kay picture chart, letter logMAR chart, illiterate E logMAR chart and 0.3 logMAR screening chart. The 0.3 logMAR screening chart was similar to that described by Keefe et al (1996). The Minimum Angle of Resolution (MAR) is the angular size of the critical detail in an optotype (Bailey & Lovie – Kitchin 2013). The logarithm of the MAR (logMAR) is an accessible approach to recording VA (Bailey & Lovie – Kitchin 2013). Normal distance VA was classified as presenting unaided distance VA < 0.32 logMAR (≥ 6/12 or ≥ 2.09 MAR). The right eye was examined first; followed by the left eye. The eye was occluded by a student optometrist holding an opaque occluder. The child passed the vision screening test if they could read four or more letters from the 0.3 logMAR line with each eye separately. Participants had difficulties using standard VA charts, mainly because of literacy problems, and a number of simplified distance VA charts were used instead for some study subjects. In the case of the illiterate E the child was asked to identify the orientation of the gaps in the “E” by demonstrating the direction with their hands. Reading four letters correctly on the 0.3 logMAR line has a numerical value of 0.32. VI was defined as presenting monocular VA of ≥ 0.32 logMAR (< 6/12). Analysis of the vision screening results with each chart was conducted. The rationale for which chart is recommended for future school vision screenings is outlined in Section 5.4.

NCR was carried out using a Keeler streak retinoscope (Keeler, London, U.K.) and a retinoscopy rack held in the child’s spectacle plane in a darkened corner of the classroom. The eye not being examined was not blurred. Children were asked to look at a non-
accommodative target 6 metres away. The SE was calculated using the sphere and cylinder from NCR data, based on the following equation: $SE = \text{Sphere} + \text{Cylinder} / 2$.

The number of cases of myopia, hyperopia, and astigmatism was determined using the following definition: myopia, $SE \leq -1.00\text{D}$; hyperopia, $SE > +1.50\text{D}$ and astigmatism was defined as cylinder $\leq -0.75\text{D}$. Emmetropia was classified as $SE > -1.00\text{D}$ and $\leq +1.50\text{D}$.

The preceding definitions for RE are referred to as RE category 2, the rationale for this category is based on the use of NCR for objective assessment of RE and is discussed further in Section 5.4. It was noted on each record if a child presented wearing spectacles.

Where more than one ocular abnormality was observed each condition was noted. The most serious or sight limiting condition was used in the data analysis. Children with active sight or life threatening pathology requiring ophthalmological attention were given a letter of referral with a date to attend Nampula Central Hospital Ophthalmology Department. A list of the children requiring treatment was also given to the school principal who agreed to follow up with the children’s parents. Children with mild infections such as conjunctivitis were advised on hygiene and sanitation.

5.2.4 Ethics

A letter explaining the study was delivered to the following authorities and permission granted by them to carry out the screening: University of Lúrio, the Provincial Departments for Health and Education in Nampula, the head of ophthalmology in Nampula Central Hospital and the school principals. After full verbal explanation of the
eye examination by a Mozambican optometry student, fully informed assent was obtained from participating children. At any time children could opt out of the study. Ethics approval was granted in 2010 from the Dublin Institute of Technology Ethics Committee.

5.2.5 Data collection and analysis

Data collection

Results were collected on the screening record form (Appendix 5.1). Forms were reviewed for accuracy and completeness in the field by the principal investigator (A.P.). Manual data was stored in a locked suitcase in Nampula and transported to Ireland in the principal investigator’s hand luggage. In Ireland, when not in use manual data was stored in a locked filing cabinet in DIT. Initial data entry for the study was carried out using MS Office Excel. The data was anonymised by using an individual code for each participant for data security and confidentiality purposes. The file with the code was kept separate to the anonymised data. The data was then transferred to the statistical package IBM SPSS Version 22 (SPSS Inc., Chicago, Illinois, USA), where error checking including outlier rechecking was carried out prior to statistical analysis.

Statistical methods/data analysis

The statistical software package IBM SPSS Version 22.0 (SPSS Inc., Chicago, IL, USA), was used for analysis. The 5% level of statistical significance for hypothesis tests, and 95% confidence intervals for means, proportions and correlation coefficients were used throughout all statistical analyses, without adjustment for multiple testing. Quantitative
outcome variables analysed in this study included SE, sphere only, cylinder, logMAR VA. The distributions of these variables were checked for normality using the Kolmogorov-Smirnov test, and non-parametric methods (the Mann Whitney U test) were used when non-normality was detected. Results for right and left eyes of each subject were compared using appropriate correlation methods. Subsequent analyses were mostly confined to right eyes only (following standard practice in the majority of RE prevalence studies (Junghans & Crewther 2005)). This method of analysis avoids data duplication which can impact on the statistical significance of the results (Newcombe 1987). Histograms and box plots were used for graphical analysis/presentation of quantitative variables.

Categorical outcome variables analysed in this study included myopia, hyperopia, astigmatism, emmetropia, RE category, pathology and vision screening result. Categorical explanatory variables included gender, location and age group. Bivariate analyses of these categorical variables were based on the standard chi-squared test for contingency tables. Pie charts and bar charts were used for graphical analysis/presentation of categorical variables.

RE was described using two different categories. Category 1 is the classification of RE as outlined by Negrel et al. (2000) for the RESC studies. It defines myopia as $SE \leq -0.50D$ and hyperopia as $SE \geq +2.00D$. Category 2 was derived from this study it defines myopia as $SE \leq -1.00D$ and hyperopia as $SE > +1.50D$. 
Relationships of study outcome variables to the demographic explanatory variables were investigated by logistic regression for binary outcome variables (such as myopia yes/no), and by general linear model analysis when the outcome was quantitative (e.g. right eye SE).

Sensitivity and specificity statistics were calculated in order to assess and compare the different vision screening approaches (chart types) which evolved in the course of this study.

The study sample was a targeted cohort of children and not a random sample, and it was collected in only one province in Mozambique. Following the usual practice for these studies, hypothesis test p-values and confidence intervals are reported here, including intervals for estimates, but these should be treated circumspectly as, strictly speaking, inference cannot be made from this non-random sample to the population of children in Nampula or Mozambique. As many subjects in this study were selected due to a perceived higher risk of poor ocular health, our estimates may be on the high side.
5.3 Results

5.3.1 Demographic profile

A total of 749 children completed the screening and are included in this study. Of these children 379 (50.6%) were male and 370 (49.4%) were female.

The age range was 4 - 18 years of age and the mean age was 10.11 ± 2.58 years. Figure 5.3.1 shows the age distribution of the participating children. The majority of children (nearly 60%) were in the 9 - 12 years age bracket; more than 96% were aged between 5 and 14 inclusive.

**Figure 5.3.1: Age distribution of the participants**

The age profile of the children who participated in this study with the percentage of total participants above the corresponding bar: 18.7% were 12 years old, 0.3 % were 4 and 18 years old.
Figure 5.3.2 shows the distribution by locality of the participating children; all three localities are well represented in this study. Figure 5.3.3 shows that boys and girls were relatively evenly represented in all three localities.

*Figure 5.3.2: Distribution of the participants by locality*

*The distribution of children by locality: 27.4% were in urban schools, 36.6% were in semi-urban schools and 36% were in rural schools.*
The gender distribution of participants by location of school was: urban (50.2% female and 49.8% male), semi-urban (46.4% female and 53.6% male) and rural (51.9% female and 48.1% male).

A more complex demographic picture emerges, however, when one considers the three variables jointly – see three-way contingency table in Appendix 5.2. In this table, just 36% of the 12 - or - over age group in the urban school are female, compared with 49.8% female in this age group in the semi-urban school and 51.9% in the rural school. Given these findings, statistical confounding is an issue (effect of age on myopia, say, may be partly an effect of gender), and in order to cater for this, the analyses reported below, of the relationship of study outcome variables (such as myopia) to the demographic variables are presented for age, sex and location jointly rather than individually.
5.3.2 Refractive error

5.3.2.1 Spherical equivalent

The SE was calculated. Right eye SE data was used for analysis in this study because of the strong correlation between right eye and left eye data (in this study, Spearman’s rho $r_s = 0.80$, 95% CI [0.76 - 0.84]). The distribution of SE was assessed for normality using the Kolmogorov-Smirnov test. The mean SE for the right eye, as determined by NCR, was +0.77 ± 0.93, 95% CI [0.69 - 0.83]. The distributions of RE expressed in SE for the right eyes are shown in Figure 5.3.4.
Refractive error is expressed as spherical equivalent (age 4 - 18 year old children, right eyes). The black continuous line represents the expected values if the data has a standard normal distribution.

The distributions of refractive error in Figure 5.3.4 show a negative skewness (data to right of graph) and a positive kurtosis (data peaks centrally). There are some outliers to the SE mean (+0.77 95% CI [0.69 - 0.83]) with a 5% trimmed mean (+0.81 95% CI [0.77 - 0.84]). The trimmed mean does not include the top and bottom 5% of SE values (or outliers) recorded. In this study the mean and trimmed mean are very similar so the
outliers are included in analysis (Pallant 2013). The Kolmogorov-Smirnov test for normality showed a significance value of \( p = 0.00 \) this indicates non normal distribution which is common in larger samples (Pallant 2013).

There was a strong correlation between the right eye SE and right eye sphere only measurements (Spearman’s \( r_s = 0.89, p = 0.00 \)). The SE (mean +0.77 ± 0.93, 95% CI [0.69 - 0.83]) rather than sphere only (mean +0.87 ± 0.92, 95% CI [0.8 - 0.94]) was used in this study as the SE is used in the majority of prevalence papers (Table 2.1).

### 5.3.2.2 Refractive error categories

The data was further divided into two categories to examine the effect of using two different classifications of RE currently in use (as discussed in Section 5.2.5). The two categories were:

**Category 1:** myopia, SE ≤ -0.50D; hyperopia, SE ≥ +2.00D.

**Category 2:** myopia, SE ≤ -1.00D; hyperopia, SE > +1.50D.

In category 1, there were 25 (3.3%, 95% CI [2.0% - 4.6%]) cases of myopia in this study, and 31 (4.1%, 95% CI [3.75% - 4.45%]) cases of hyperopia. Category 2 (SE ≤ -1.00D and > +1.50D) was also used which helps to compensate for the use of NCR, which can underestimate the number of hyperopes and over estimate the number of
myopes (see discussion). This category showed a reduction in the number of myopic cases to 18 (2.4%, 95% CI [1.3% - 3.5%]) and an increase in the number of hyperopic cases to 49 (6.5%, 95% CI [6.2% - 6.7%]). In summary using category 2 URE was detected in 8.9%, 95% CI [8.7% - 9.1%] of school children. The category 2 classification was adopted for subsequent statistical analysis of myopia and hyperopia.

The maximum RE measured among the children in this study were $-11.00D$ (SE) for myopia, $+5.00D$ (SE) for hyperopia, and $-6.00DC$ for astigmatism. All these were previously undiagnosed and uncorrected.

**Astigmatism**

There was a fairly strong positive correlation between the cylinder value in the right and left eyes (Spearman’s rho $r_s = 0.52$, 95% CI [0.45 - 0.59]). Only cylinder data from right eyes was used for the refractive class analysis. The astigmatism measure, using the cylindrical component of the prescription for the right eye of the sample data, had a mean of $-0.22D \pm 0.52$ (SD), 95% CI for mean [-0.25 - -0.18]. There were 48 (6.4%, 95% CI [4.7% - 8.1%]) cases of astigmatism (cylinder $\leq -0.75D$) in this study.

**5.3.3 Spectacle coverage**

In the present study spectacle coverage was 0.00% i.e. none of the children presented wearing spectacles. Thus, children found to have vision reducing RE were not wearing
spectacles. If myopia SE ≤ -1.00D is used as a prescribing criterion 18 (2.4%) children would be considered myopic and should have spectacles dispensed. If hyperopia SE > +1.50D is used as a prescribing criterion 49 (6.5%) hyperopic children would benefit from spectacle prescription. If the best case scenario from both RE classification categories are used i.e. myopia SE ≤ -1.00D (2.4%, 18 cases) and hyperopia SE ≥ +2.00D 31 (4.1%, cases) this would still mean that in the current sample 6.5% of children would have benefited from spectacles. If astigmatism cylinder ≤ -0.75DC is used as a prescribing criterion, 48 children (6.4%) had significant astigmatism and should have correction.

5.3.4 Ocular abnormalities

In total 747 children had complete screening data including ophthalmoscopy. Ocular abnormality was detected in 90 (12%, 95% CI [9.7% - 14.3%]) of the 749 children screened. The main ocular abnormality detected in each child was grouped into categories, similar to those used in the RESC studies (Maul et al. 2000; Pokharel et al. 2000; Zhao et al. 2000; Dandona et al. 2002; Murthy et al. 2002; Naidoo et al. 2003; He et al. 2004; Goh et al. 2005), and shown in Figure 5.3.5 and Table 5.3.4. Glaucoma was suspected in 26 children, anterior segment disease in 17 children and corneal opacity in 14 children, retinal disorder in 8 children and cataract in 7 children. Strabismus and ocular albinism were found in 5 and 3 children respectively. In 2 cases the ophthalmoscopy was not recorded, pathology was noted but not defined in 7 cases (unexplained); the pathology did not readily fit into the categories in 3 cases (other –
scleral thinning, 2 nystagmus). Retinal disorders included solar maculopathy, retinal scarring, retinal detachment, morning glory and optic disc coloboma. The anterior segment disease category included, but was not limited to, entropion, conjunctival infection, hyperaemia, ptosis, trichiasis and one case of suspected melanoma.

***Figure 5.3.5: Summary of pathology detected***

The pie chart shows that the majority of children had healthy eyes, with glaucoma (n = 26), anterior segment disease (n = 17), corneal opacity (n = 14), retinal disorder (n = 8) and cataract (n = 7) among the most common pathologies detected.
5.3.5 Visual screening

Vision screening was carried out for 745 children in this study. In total 56 right eyes and 70 left eyes failed to read four or more letters on the 0.3 logMAR line. In 86 cases one or both eyes failed to meet the cut off as shown in Table 5.3.1.

Table 5.3.1: Number of eyes which had visual acuity of worse than 0.32 logMAR

<table>
<thead>
<tr>
<th>Visual Acuity worse than 0.32 logMAR (&lt; 6/12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Eyes</td>
</tr>
<tr>
<td>56 (7.5%)</td>
</tr>
</tbody>
</table>

The % values given represent the percentage of eyes that failed the vision screening out of the total number of eyes screened. The % is broken down into right (7.5%), left (9.3%) and both eyes (11.5%) failing to see four or more letters on the 0.3 logMAR line or equivalent line on; the VA chart.

7.5% of right eyes, 9.3% of left eyes and 11.5% of children failed the vision screening as either one or both eyes failed to achieve unaided distance VA of 0.32 logMAR (6/12) or better.

5.3.6 Causes of vision impairment

5.3.6.1 Vision impairment due to refractive error

3.6% of the total targeted sample had VI due to URE. Of the 18 children with myopia, 16 (88.9% of myopes) failed the screening test. Of the 49 children with hyperopia only 11 (22.4% of hyperopes) failed the screening test. Thus, the VI screening had good sensitivity (89%) for myopia but poor sensitivity (23%) for hyperopia detection. The VI
screening showed good specificity for myopia (91%) and hyperopia (93%). As outlined in Table 5.3.2, the screening correctly identified that 619 children (82.6% of total sample) did not have URE as detected by NCR i.e. specificity was good. The screening test failed 59 children who were subsequently found to not have URE with NCR.

Table 5.3.2: Distribution of participants by uncorrected refractive error and outcome of vision screening

<table>
<thead>
<tr>
<th>Vision Screening outcome</th>
<th>Myopia number (% outcome)</th>
<th>Emmetropia number (% outcome)</th>
<th>Hyperopia number (% outcome)</th>
<th>( \chi^2 ) = 117.51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail</td>
<td>16 (18.6)</td>
<td>59 (68.6)</td>
<td>11 (12.8)</td>
<td></td>
</tr>
<tr>
<td>Pass</td>
<td>2 (0.3)</td>
<td>619 (93.9)</td>
<td>38 (5.8)</td>
<td>( p = 0.00 )</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18 (2.4)</strong></td>
<td><strong>682 (91.1)</strong></td>
<td><strong>49 (6.5)</strong></td>
<td></td>
</tr>
</tbody>
</table>

There is a significant relationship between the vision screening outcome of children by uncorrected refractive error as defined by category 2 (Myopia \( \leq -1.00 \) D and Hyperopia \( > +1.50 \) D).

5.3.6.2 Vision impairment due to ocular abnormality

Out of the 747 children with an ocular health assessment conducted 743 children also had vision screening performed. Among this cohort of children 589 (90.2%) children with no ocular abnormality present passed the vision screening (specificity 90%) as shown in Table 5.3.3. Of the 90 children with ocular abnormalities 69 passed the vision screening test. Thus, 21 children with pathology failed vision screening (sensitivity= 23%, poor).
Cataract, corneal opacity and ocular albinism generally affect vision. Vision screening identified only 28.6% of corneal opacity cases, 42.9% of cataract cases and 66.7% of ocular albinism cases.

**Table 5.3.3: Distribution of participant by ocular health and vision screening outcome**

<table>
<thead>
<tr>
<th>VA Screening Outcome (% of ophthalmoscopy outcome)</th>
<th>n = 743</th>
<th>Pass</th>
<th>Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td></td>
<td>589</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90.20%</td>
<td>9.80%</td>
</tr>
<tr>
<td>Ocular Abnormality</td>
<td></td>
<td>69</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>76.70%</td>
<td>23.30%</td>
</tr>
</tbody>
</table>

Breakdown of ocular health as detected by ophthalmoscopy and VA screening outcome. Fail – failure of one or both eyes to read 4 or more letters from the 0.3 logMAR line. There was a significant link between presence of ocular abnormality and vision screening outcome p <0.05.

Table 5.3.4 highlights children with ocular abnormalities who also failed the vision screening test. Not all ocular abnormalities detected were sight threatening or in need of referral. Glaucoma, anterior segment disease and corneal opacity had the highest number of passes on the VA screening test.
Table 5.3.4: Summary of ocular abnormalities detected by pathology and VA outcome

<table>
<thead>
<tr>
<th>Summary of Pathology Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ophthalmoscopy result</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>Number</td>
</tr>
<tr>
<td>Healthy</td>
</tr>
<tr>
<td>Not Recorded</td>
</tr>
<tr>
<td>Ocular Abnormality</td>
</tr>
<tr>
<td>Glaucoma</td>
</tr>
<tr>
<td>Anterior Segment Disease</td>
</tr>
<tr>
<td>Corneal Opacity</td>
</tr>
<tr>
<td>Cataract</td>
</tr>
<tr>
<td>Retinal Disorder</td>
</tr>
<tr>
<td>Unexplained</td>
</tr>
<tr>
<td>Strabismus</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Ocular Albinism</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Ocular abnormality was detected in 90 of the 747 cases. 21 children with pathology also had reduced VA. Not Recorded - not coded healthy or unhealthy or no vision screening result recorded, (2/749 children had no ophthalmoscopy result, 6/749 had no vision screening result); Other - ocular abnormality does not fit in the categories; Unexplained - recorded unhealthy no description of condition given; fail - failure to see 0.32 logMAR on a chart with either or both eyes.

5.3.7 Investigation of influence of gender, age and location on refractive error

As explained in Section 5.3.1 above, because of interdependence among the demographic variables, presentation of results separately for age and gender could be misleading.

Instead the analysis was performed on the relationship of our outcome variables (prevalence of myopia etc) to age, gender and location jointly. Myopia and hyperopia in these analyses are based on the category 2 (Section 5.3.2.2 above). In addition, the
quantitative measurement of RE, right eye SE was used. Three age categories were employed in these analyses: 4 - 8, 9 - 11 and 12 - 18 years of age. Logistic regression analysis was used for these analyses when outcome variables were binary (e.g. myopia yes/no). Detailed statistical output from these analyses is provided in Appendix 5.2.

It is seen in Appendix 5.2 that, whichever RE outcome is analysed, there is no statistically significant relationship between this outcome and any of the demographic variables. In particular, controlling for gender and school, there is no statistically significant age effect in this study; older children do not exhibit significantly greater prevalence of myopia or hyperopia.

Table A 5.2.4 in Appendix 5.2 shows the breakdown of URE (category 2) by locality. The least amount of myopia was detected among the rural children (0.7%). However there is no significant association between locality and URE Pearson Chi Squared 0.913, p = 0.92.

The vast majority of children in this study had a RE between 0.00D and +1.00D as demonstrated in Figure 5.3.4 and Figure 5.3.6. It is interesting to note however that there are some cases of hyperopia and myopia greater than ±2.00D among several age groups in this cohort. The highest myopic prescription was -11.00D SE, the highest hyperopic prescription was +5.00D SE, the highest astigmatism; measured was -6.00DC.
Age ranged from 5 - 15 years, RE measured with noncycloplegic retinoscopy. Each box covers the 25th to the 75th percentile of the distribution (interquartile range) with the bar inside representing the median. Whiskers extend to the lower and upper extremes. Outliers are represented by the symbol (•). RE outside these extremes which are not shown these include 4 hyperopic NCR results >+3.00D and 5 myopic NCR results > -3.00D. Children aged 4 (n = 2), 16-18 (n = 14), were also removed from this chart as the number in these age groups were very low; these children were not responsible for extreme RE values.
5.3.8 Vision screening charts

5.3.8.1 LogMAR visual acuity measurements: Day 1 & 2, 2010

Initially VA was measured as described by Negrel et al. (2000) in the RESC protocol (starting at 1.0 logMAR then progressing down the chart) with the Letter or Illiterate E logMAR chart at 4 metres). This method was conducted for the first 164 children. Table 5.3.5 and Figures 5.3.7 and 5.3.8 give a summary of the monocular logMAR VA values achieved by these children.

Table 5.3.5: Distribution of logMAR visual acuity in the sample of 164 children (right eye and left eye)

<table>
<thead>
<tr>
<th></th>
<th>Right Eye</th>
<th>Left Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean logMAR VA</td>
<td>0.13</td>
<td>0.15</td>
</tr>
<tr>
<td>95% CI</td>
<td>[0.11 - 0.16]</td>
<td>[0.13 - 0.18]</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>± 0.18</td>
<td>± 0.17</td>
</tr>
</tbody>
</table>

Mean logMAR VA left eye 0.15 ± 0.17 is slightly worse than right eye 0.13 ± 0.18.
Figure 5.3.7: Distribution of the logMAR visual acuities (right eye) in 164 children.

Distribution of the right eye logMAR visual acuities for the 164 children. The black continuous line represents the expected values if the data have a standard normal distribution.
Figure 5.3.8: Distribution of the logMAR visual acuities (left eye) in 164 children.

Distribution of the left eye logMAR visual acuities for 164 children. The black continuous line represents the expected values if the data have a standard normal distribution.
The initial method of VA measurement used on 164 children demonstrated a high mean VA for both right (0.13 ± 0.18 logMAR/1.54 ± 1.28 MAR) and left (0.15 ± 0.17 logMAR / 1.57 ± 0.92 MAR) eyes, as shown in Table 5.3.5. The logMAR VA for the right and left eye shows a moderate correlation Spearman’s Rho $r_s = 0.675$ $p = 0.00$. Measuring the precise monocular VA for each child was time consuming due to several factors including the language barrier between examiners and children.

5.3.8.2 Vision screening represented by pass/fail outcome

The measurement of VA (2010 day 1 & 2) and screening of vision evolved throughout this study. Several methods of vision screening were investigated to evaluate the outcome (pass/fail) as measured by each chart type and suitability of the chart to the study setting. The outcomes of each chart type are shown in Table 5.3.6 and are outlined in more detail below.

In order to streamline the vision screening so that more children could be examined in less time, vision screening with a simple pass/fail outcome was conducted. On day 3 of the CEH screening conducted in 2010, children were directed to read the 0.3 logMAR line of the Letter or Illiterate E logMAR chart at 4 metres or the 0.3 logMAR equivalent line of the Kay Picture Crowded logMAR chart at 3 metres. Table 5.3.6 also shows the number of children screened by each of these charts in 2010.
Table 5.3.6: Vision screening outcome according to the visual acuity chart used

<table>
<thead>
<tr>
<th>Day and Year of Screening</th>
<th>Visual acuity chart type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Letter or Illiterate E</td>
</tr>
<tr>
<td></td>
<td>% of Chart</td>
</tr>
<tr>
<td>Visual outcome</td>
<td></td>
</tr>
<tr>
<td>Pass</td>
<td>84.1%</td>
</tr>
<tr>
<td>Fail</td>
<td>15.9%</td>
</tr>
<tr>
<td>Total</td>
<td>21.9%</td>
</tr>
</tbody>
</table>

No. - number of cases; Fail - fail on one or both eyes; % of Chart - % of cases tested with that Chart; % of Total - % of total number of cases. Out of 745 children with VA data, 659 children passed the vision screening. 86 children failed the vision screening with one or both eyes. 0.3 logMAR screening chart was used for the majority of children.

On review of each of the screening methods above and the literature on vision screening, it was decided that a simple one line screening test chart would be designed for further screening. The rationale for this is further explained in Section 5.4. A “0.3 logMAR screening chart” was designed and utilised in 2012 (Figure 5.3.9). This chart consisted of one line of 5 Illiterate E letters equivalent to 0.3 logMAR when held at 4 metres. After testing the right eye the chart was rotated for the left eye to prevent learning of the letter
sequence. The number of children screened and their outcome from vision screening with this chart is shown in Table 5.3.6.

*Figure 5.3.9: 0.3 logMAR screening chart*

To pass the screening the child must correctly identify the orientation of four letters on the 0.3 logMAR screening chart. This equates to 0.32 logMAR. Diagram not to scale. Several versions with different combinations of illiterate E orientations were used.

### 5.3.8.3 Specificity and sensitivity of vision screening methods

Table 5.3.7 expresses the specificity and sensitivity of the vision screening outcome for either or both eyes at detecting URE. In this study, as expected, the VA charts were highly effective at identifying the number of children with myopia (sensitivity 75% - 100%) and those who did not have myopia (specificity 86% - 98%). The VA charts were also effective at identifying those who did not have hyperopia (specificity 84% - 95%) but were not effective at identifying the number of children with hyperopia (sensitivity 0
- 26%). Overall the charts were accurate at detecting the children who did not have URE (specificity 86% - 98%). But the charts had varying accuracy at detecting the children with URE (sensitivity 36% - 100%).

Table 5.3.7: Sensitivity and specificity of each vision chart for the detection of refractive error (category 2)

<table>
<thead>
<tr>
<th>Chart Title</th>
<th>Chart Code</th>
<th>Number tested</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter or Illiterate E logMAR</td>
<td>1</td>
<td>n = 164</td>
<td>75</td>
<td>86</td>
<td>0</td>
<td>84</td>
<td>60</td>
<td>86</td>
</tr>
<tr>
<td>Kay Picture Chart</td>
<td>2</td>
<td>n = 56</td>
<td>100</td>
<td>98</td>
<td>0</td>
<td>95</td>
<td>67</td>
<td>98</td>
</tr>
<tr>
<td>Letter logMAR Chart</td>
<td>3</td>
<td>n = 28</td>
<td>100</td>
<td>89</td>
<td>n/a</td>
<td>86</td>
<td>100</td>
<td>89</td>
</tr>
<tr>
<td>Illiterate E logMAR Chart</td>
<td>4</td>
<td>n = 65</td>
<td>100</td>
<td>89</td>
<td>0</td>
<td>84</td>
<td>75</td>
<td>89</td>
</tr>
<tr>
<td>0.3 logMAR Screening Chart</td>
<td>5</td>
<td>n = 432</td>
<td>88</td>
<td>92</td>
<td>26</td>
<td>92</td>
<td>36</td>
<td>94</td>
</tr>
</tbody>
</table>

The sensitivity and specificity for each chart at detecting URE (myopia, SE ≤ -1.00D; hyperopia, SE > +1.50D) is shown. n/a – there were no cases of hyperopia in this cohort so the sensitivity could not be calculated. Each VA chart showed very high sensitivity (75 - 100%) and specificity (86 - 98%) for myopia. Each VA chart showed high specificity for hyperopia (84 - 92%) but relatively low sensitivity (0 - 26%) for hyperopia.
5.3.8.4 Further observations on vision screening

When the highest and lowest values for SE were isolated, the five most myopic children (range -11.00D SE to -3.50D SE) failed the screening. However, five of the most hyperopic children (range +5.00D SE to +3.00D SE) passed the vision screening. The five most hyperopic children who failed the screening had URE of +3.00D SE to +2.50D SE.

The four children with the most significant hyperopia (+5.00D, +3.50D, +3.25D, +2.50) in addition to a pass result on the vision screening test had an ocular anomaly (strabismus, cataract, retinal disorder, corneal opacity respectively).
5.4 Discussion

Nearly 750 children were tested in this study which was the first optometry led school eye health screening carried out in Mozambique. The distribution of children according to gender and locality was almost equal. The age distribution peaked at age 12 with the majority of children aged 9 - 12 years. Very few children aged four or 14 - 18 were tested. This age distribution may be due to the Mozambique school system operating a shift system, with four shifts per day. Each shift caters for a particular age group. The study was conducted between 7.30am - 3pm each day. This is the time when children aged 9 - 12 years attend school.

The results of this study provide data on the NCR refractive status of a targeted cohort of school going children in Nampula, Mozambique. The main outcomes of study 1 were that it was feasible to carry out an optometry led CEH school screening in Nampula and that NCR detected URE, according to category 2, was present among 8.9% of the children screened. The NCR results detected a low amount of myopia (3.3%) and hyperopia (4.1%) using category 1 (myopia, SE ≤ -0.50D; hyperopia, ≥ +2.00D) RE classification. Using category 2 (hyperopia SE > +1.50D), the amount of hyperopia (6.5%) found in this study cohort by NCR is slightly higher to the prevalence found in the South African RESC (1% - 2%) with cycloplegic retinoscopy (Naidoo et al. 2003). The amount of myopia (myopia SE ≤ -1.00D) in this study (2.4%) was low compared to the myopic prevalence found in the RESC which increased up to 9.6% in 15 year olds. This may be due to the very limited number of teenagers taking part in this study. Although even the 12 year old children tested in this study had low levels of myopia, possibly due to the
limited number of children in this study compared to prevalence studies or maybe some myopic children are not in school in Mozambique. Astigmatism was found in 6.4% of right eyes in this study with NCR, comparing well to the astigmatism prevalence found in the South African RESC (6.7%) with cycloplegic retinoscopy.

Table 5.4.1: Prevalence estimates for Nampula and Mozambique

<table>
<thead>
<tr>
<th>Type of URE</th>
<th>South Africa RESC URE Category 1</th>
<th>Mozambique Study 1 URE Category 1</th>
<th>Mozambique Study 1 URE Category 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number</td>
<td>% prevalence</td>
<td>number</td>
</tr>
<tr>
<td>Myopia</td>
<td>80,000</td>
<td>4%</td>
<td>66,000</td>
</tr>
<tr>
<td>Hyperopia</td>
<td>52,000</td>
<td>2.6%</td>
<td>86,100</td>
</tr>
<tr>
<td>Astigmatism</td>
<td>140,700</td>
<td>6.7%</td>
<td>128,000</td>
</tr>
<tr>
<td>Total</td>
<td>272,700</td>
<td>13.3%</td>
<td>280,100</td>
</tr>
</tbody>
</table>

Nampula (2.1 million children)

<table>
<thead>
<tr>
<th>Type of URE</th>
<th>South Africa RESC URE Category 1</th>
<th>Mozambique Study 1 URE Category 1</th>
<th>Mozambique Study 1 URE Category 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number</td>
<td>% prevalence</td>
<td>number</td>
</tr>
<tr>
<td>Myopia</td>
<td>453,600</td>
<td>4%</td>
<td>374,220</td>
</tr>
<tr>
<td>Hyperopia</td>
<td>294,840</td>
<td>2.6%</td>
<td>464,940</td>
</tr>
<tr>
<td>Astigmatism</td>
<td>759,780</td>
<td>6.7%</td>
<td>725,760</td>
</tr>
<tr>
<td>Total</td>
<td>1,508,220</td>
<td>13.3%</td>
<td>1,564,920</td>
</tr>
</tbody>
</table>

Mozambique (11.34 million children)

South Africa RESC URE Category 1 - Prevalence rates from the South African RESC study are used on the Mozambique child population using category 1 (myopia, SE ≤ -0.50D; hyperopia, SE ≥ +2.00D). Mozambique Study 1 URE, Category 1 - Study 1 category 1 detection rates are projected onto the child population. % detected - instead of prevalence figures the % detected is used as study 1 was conducted on a targeted cohort. Mozambique Study 1 URE Category 2 - detection rates for Study 1 category 2 (myopia, SE ≤ -1.00D; hyperopia, SE > +1.50D) are used on the child population. Prevalence estimates for the number of children in Nampula with URE range from 272,700 – 312,500.

Table 5.4.1 illustrates the estimated number of children with URE in Nampula and Mozambique. Firstly the prevalence rate from the South African RESC was applied to the
child population. Subsequently the percentage detection rates from study 1 using each of the two categories outlined in Section 5.2.3 were applied to the child population. The RESC rate yielded the lowest total estimate of children potentially negatively affected by URE. However it is clear that if any of these rates are utilised over 270,000 children in Nampula and more than 1.5 million children in Mozambique may be living with significant URE.

The RARE and RAAB methodology and classification of URE, outlined in Section 2.3, differed to the study 1 methodology. Study 1 found the pinhole method difficult to explain to the children, with spurious results obtained, so it was quickly abandoned on each screening visit. Instead, NCR was the chosen method for determination of the presence of URE, this also enabled classification of different URE types. The RAAB and RARE gave the prevalence of all URE and did not classify it as myopia, hyperopia or astigmatism.

Naidoo et al. (2003) concluded from the 10.8% of children in the RESC study presenting with external and anterior ocular abnormalities (mainly eyelid, corneal scarring, conjunctival and pupillary abnormalities) that there was a dearth of eye care services or uptake of services in the Durban area. A similar conclusion is obvious in Nampula given that ocular pathology was detected in 90 (12%) of school children. Rates of lenticular and retinal abnormalities are similar but interestingly the RESC study reported one aphakic child, two children with bilateral pseudophakia and one child with a prosthetic eye. There was no such evidence of ocular surgery in the children screened in study 1.
Among the total sample in study 1, 3.6% failed the vision screening and were found to have URE. The 3.6% VI rate compares well with the 3.5%, 95% CI [2.7% - 4.2%] VI prevalence rate detected by Loughman et al. (2014) in the Mozambique RARE. The RARE was conducted on adults aged 15 - 50 years old. The RARE found that 66% of those with VI were 35 years of age or older (Loughman et al. 2014). The 3.6% VI rate is relatively high when loose comparisons are made with other African school (similar age groups) vision studies such as in South Africa where only 1.4% had uncorrected VA of 0.32 or worse (Naidoo et al. 2003).

Other African studies report that 2.3% of school children in Ghana (n = 1103) had VA < 6/18 to 3/60 (Ovenseri - Ogbomo 2010); 1.7% rural primary school children in Tanzania had VA < 6/12 (n = 1438) (Wedner et al. 2000). A higher rate of 6.1% was reported in urban Tanzanian secondary school children who had VA worse than 6/12 (Wedner et al. 2002) in one or both eyes. The Tanzanian secondary school study had a larger number of older children participating in their study compared to study 1. As expected both RAAB studies in Sofala (17.5%) and Nampula (9.4%) reported a higher prevalence of VI than study 1 (Kimani et al. 2011, Bedri 2014). This is due to the RAAB purposively targeting the older population (adults > 50 years old) as they are more likely to have VI. Both RAAB studies concluded that URE was one of the main causes of VI in adults 50 years and over. As all the studies on VI among various age groups in Mozambique, including study 1, estimate URE to be a leading cause of VI then it is clear that URE is a public health concern which should be included in national health planning. If 3.2% of the child
population of Mozambique had VA $\geq 0.32$ logMAR ($< 6/12$) then 67,200 children in Nampula and 362,880 children in Mozambique would have reduced VA. As outlined in the Chapter two reduced VA can have a devastating effect on the child (Gilbert & Foster 2001).

The high VI rate (11.5%) detected in study 1 is contrary to the expectation that a screening method would have a higher pass rate since a one line acuity test is easier to read than a full chart (Morad et al. 1999). Not all the children who failed the vision screening (11.5%) had URE (Table 5.3.3) or pathology (Table 5.3.4). The number of children presenting with reduced VA who actually had URE was 27 (31.4% of fails, 3.6% of total). Just less than 60% of children who failed the vision screening did not have significant URE. These children could have been malingering, but this was not investigated. If the vision screening was used as a device to determine which children would receive a full eye examination, it would waste resources because many of the children who failed did not have URE or ocular pathology.

The research team mainly spoke English and Portuguese. The Mozambican optometry students spoke their own local dialect (Makua and others) in addition to Portuguese. Older children spoke Portuguese and Makua, however, younger children spoke only their own local dialect (mainly Makua). The statistical analysis does not illustrate that the 0.3 logMAR screening chart was much easier to screen with, because it did not require the child to have the same language as the screener. The Illiterate E optotype did not require the child to be literate, which was another necessary attribute of the chart, due to the
varied level of literacy among children. Study 1 advocates for the use of the 0.3 logMAR screening chart for school vision screening.

At the time of the screenings there was a small faculty of optometry lecturers in Mozambique (n = 2 (2010), n = 5 (2012)). Optometrists and optometry students from Ireland assisted in the research.

All the charts performed well at detecting children with myopia (maximum sensitivity - 100) and those without (maximum specificity - 98), as expected. However the 0.3 logMAR screening chart had the highest sensitivity (40%) and a very high specificity (93%) for hyperopia detection. This may be due to the larger number of children tested with this chart therefore there was a higher chance that it would detect hyperopia. As expected, all charts did not detect hyperopia to a satisfactory level. This is because children with under approximately +2.50D often have good distance vision as their active accommodation can compensate for their hyperopia. In an attempt to detect hyperopes using the vision screening a +2.00D blur test was used initially in 2010 and 2012. This test was abandoned quickly each year by the researchers as it was too time consuming and difficult to explain to the children. Near vision was assessed using several types of near charts (N Chart, Letter and Illiterate E logMAR) on Day 1 and 2, 2010 but results were not analysed as the chart type was not recorded. Further research is recommended to investigate the necessary cut off value and the sensitivity of a one line logMAR illiterate E near vision chart at identifying hyperopes.
Based on the findings from this study, the 0.3 logMAR screening chart is a very cheap, reproducible, easy to use tool which could be used to accurately detect the majority of children with myopia. The Illiterate E chart may over estimate VA compared to a letter chart (Bourne et al. 2003). This is because there are only four possible for the E outcomes compared with 26 possible outcomes for the letter chart. The Kay chart was reported to overestimate VA by one line in amblyopes (O’Boyle & Little 2015). The addition of a surrounding crowding bar, similar to the Glasgow Acuity Cards, ought to increase the sensitivity of the chart to detecting amblyopes (Simmers et al. 1997).

A large number of vision screening false positives were identified through NCR which is a quick objective method. Subsequent to vision screening NCR should be conducted on those children who fail the vision screening as it would further reduce the number of false positives. The subsequent lower rate of VI due to URE (3.2%) suggests that NCR or an objective method of screening will ultimately reduce costs by prevention of many false positives entering the already over-burdened primary care system. This study recommends that initially optometrists, upskilled ophthalmic technicians, or personnel proficient in NCR examine the children who fail the vision screening. Using eye care personnel increases the cost of screening and takes these personnel from primary care services. Thompson et al. (2014b) performed a cost benefit analysis on the development of a public optometry programme in Mozambique. Thompson et al. (2014b) concluded that investment in optometry training in Mozambique be of social and economic benefit to the public.
Autorefraction is a widely used alternative method of URE detection. Rao et al. (2015) suggested teachers or lay people could potentially be trained in its use. But the initial cost and logistics involved in supplying auto refractors for Nampula school eye health screenings is prohibitive. Other issues around teachers using auto refractors would also include: concerns around security; availability of maintenance support; access to electricity is limited in some schools. One suggestion is that community health workers or teachers be trained in retinoscopy. Retinoscopes and retinoscopy lenses (ret racks) are a relatively inexpensive, robust and very portable diagnostic tool requiring very little maintenance. However retinoscopy is a skill which requires extensive training and a good basic level of maths and physics. With this in mind study 2 investigated the accuracy of teacher vision screening as this required very little training.

The vision screening alone did not detect all the children with ocular abnormalities. This may be due to the fact that not all ocular pathology affects central vision (e.g. mild conjunctivitis); the ocular pathology may not be advanced to a stage where it is affecting central vision. This has implications for screening programmes in developing countries like Mozambique where there are not enough trained eye care personnel to screen the eye health of all school children. One suggestion is that in addition to vision screening, lay screeners such as teachers should be given short training on signs, prevention and treatment of eye disease including trachoma, cataract and corneal opacity and a pen torch for ocular examination. This would mean that a child who passes the vision screening but has an obvious sign of ocular abnormality would be further assessed by an eye care
worker. Therefore, a school eye health screening should incorporate the detection of ocular pathology in addition to VI. Tengtrisorn et al. (2009) recommends that lay screeners need to be educated on signs of anterior segment disease and equipped with at least a pen torch to identify cataract and anterior segment disease. Many of the diseases detected in the children are treatable or preventable e.g. cataract, corneal opacity due to trauma, trachoma and vitamin A deficiency.

Glaucoma was the most common eye disease among the study 1 cohort. Vision screening will not detect glaucoma as the signs of this disease are internal and peripheral vision loss may not be noted by the child until the disease has progressed. Ophthalmoscopes are a relatively inexpensive, robust and very portable diagnostic tool requiring very little maintenance. However, as with retinoscopy, training is required to become proficient at ophthalmoscopy, in addition to a good knowledge of biology and pathology of the eye. Unfortunately there will be no way of screening the ocular health of all children until the lack of human resources for eye health issue is addressed in Mozambique. This will mean that many children with glaucoma will go blind from a treatable disease.

Since CEH screening began in Nampula in 2010 there have been major advances in the incorporation of mobile phone technology in disease (including ocular) screening, detection and management (Chakrabarti 2012). Free smartphone based Snellen VA charts are plentiful and may be useful for vision screening in schools. However, Perera et al. (2015) did not identify a smartphone vision test which could predict the wall chart Snellen VA to within 2 lines. The Near Eye Tool for Refractive Assessment (Pamplona et
al. 2010) was developed to RE using a pinhole and software. Several camera phone attachments have been trialled for use by lay people or eye care professionals to monitor and detect disease (Maamari et al. 2013, Livingston et al. 2014). Bastawrous (2012) describes a method of using a 20D lens and the video on a smartphone to obtain a fundus image. Smartphone images from school eye health screenings may be sent to graders in real time or uploaded to computer software on return from the field. The Portable Eye Examination Kit (PEEK Vision 2016) was developed to provide a range of tools to convert the smartphone into a tool for VA, cataract and retinal assessment. Ocular disease screening using smartphones in Nampula has immediate potential if no additional parts are required for the phone, and the images are uploaded to the network on returning from the field. There was no Wi-Fi in schools and very little access to internet and computers in Nampula. Text messaging in primary health care systems allows cheap, quick reminders of follow up appointments and preventative health care messages to be sent.

The NCR results were analysed using right eye SE. Using the SE in RE analysis underestimates the hyperopia present in subjects (Williams et al. 2008). This is due to cylindrical component having a minus value e.g. +5.00/-2.00 X 180 is equivalent to a SE of +4.00D. The SE does not describe the cylindrical element of the RE e.g. a SE of +4.00D could be as a result of a +4.00DS or a +5.00/-2.00 X 180. In this study the results for right eye sphere only and SE were compared Spearman’s rank correlation coefficient. There was no significant difference found (p = 0.00) for the outcome using the two different methods so right eye SE was used throughout this study.
The following two categories were used in this study to classify RE: Category 1: myopia, SE ≤ -0.50D; hyperopia, ≥ +2.00D and category 2: myopia, SE ≤ -1.00D; hyperopia, SE > +1.50D. Category 1 is the most common category used in RE studies, see Table 2.1. The more liberal definition of myopia ≤ -0.50D in data sets using NCR or refraction may cause a misclassification of myopia (Ruiz-Alcocer et al. 2014, Junghans 2005, Fotouhi 2012, Mohamed 2014). Myopia SE of -0.50D as determined by NCR may not be significant in a child with very active accommodation and is unlikely to impede vision (Choong et al. 2006, Fotedor et al. 2007). Therefore in a clinical setting, children with -0.50D myopia as detected by NCR may not have spectacles dispensed. Luo et al. (2006) determined RE using CAR and used various SE cut offs (-0.25, -0.50, -0.75 and -1.00) and ROC curves to determine which cut off gives the highest specificity and sensitivity, while showing functional vision impairment. Luo et al. concluded that a cut off of -0.75D is preferred for defining myopia.

The present study applied category 2 to SE data: myopia ≤ -1.00D and hyperopia > +1.50D to incur smaller errors in RE detection (Krantz et al. 2010). Category 2 allows some compensation for the underestimation of hyperopia incurred from SE analysis and the use of NCR. It also may compensate for untested eye not being blurred in younger children where hyperopia may not be fully detected due to accommodation. The untested eye was not blurred due to the length of time it would have taken to put positive spectacles on children who may have never seen spectacles before and because of the language barrier which rendered asking the children to hold a positive lens in front of the eye not being tested very difficult. Due to the need to conduct NCR vision screening in
Mozambique as opposed to cycloplegic retinoscopy (CRet) for the reasons mentioned in Section 5.4.1.1, category 2 was used as a cut off for RE since it is more likely to identify myopic and hyperopic children with functional vision impairment.

Direct logistic regression was performed to assess the likelihood of gender, locality or age being associated with myopia, hyperopia and astigmatism. Neither gender, locality, nor age, were found to be associated with myopia, hyperopia and astigmatism (Appendix 5.2). It is interesting to note that less females attended school in the older age group. This correlates with gender disparity research which indicates that girls leave school earlier than boys and that there are several barriers (household, environmental, social/cultural) to girls remaining in education in Mozambique (Roby et al. 2009).

In this study of a targeted cohort of children, females were slightly more hyperopic +0.79 ± 1.10 (SD) than males +0.73 ± 0.71 (SD) \( p = 0.00 \), Mann Whitney U test. As this was a targeted cohort, where teachers were encouraged to ask children with VI to attend, a larger proportion of URE was expected. Review of the research into the link between gender and RE in school going populations in Sub Saharan Africa revealed that in the Republic of South Africa (\( n = 4,890 \)), Ethiopia (\( n = 4,238 \)) and Tanzania (\( n = 2,511 \)) RE was more common in girls than boys (Naidoo et al., 2003 Mehari et al., 2013 Wedner et al., 2002). The South African RESC reported that the slightly hyperopic mean SE for females (+0.8 ± 1.10 (SD)) and males (+0.73 ± 0.71 (SD)) was higher than the CRet means found in their study +0.56 ± 0.65 (SD) in boys and +0.63 ± 0.91 (SD) in girls.
Ruiz-Alcocer et al. (2011) found no significant difference in RE between males and females in Mozambique, although this study had an older cohort of 17 - 26 years.

Study 1, on a targeted cohort of children indicated no significant association between age and RE distribution. Once categorised, the 9 - 11 years age group was the most myopic (1.1%). In Ghana and South Africa Kumah et al. (2013) and Naidoo et al. (2003) respectively reported a trend towards an increased prevalence of myopia as children got older. Figure 5.4.2 reproduced from Morgan et al. (2010) shows the RE distribution by age in the South African RESC. Naidoo et al. (2003) state that increasing age and parental education were both associated with myopia found by CRet and cycloplegic autorefraction. Mild hyperopia was the major trend in study 1 and in the South African children. In the South African RESC hyperopia reduced with age, with a very low prevalence of myopia even at age 15 years. A very low number of children 16 - 18 years old (n = 14) were recruited in study 1 so more research ought to be conducted for this age group. Astigmatism was also shown to be associated with increased age in the South African RESC; this was not the case in the present study.
The study population was mainly mildly hyperopic and emmetropic. Source: Morgan et al. (2010). Based on data from Naidoo et al. (2003).

There is no standard international definition for urban and rural areas (United Nations Statistics Division, 2013). Mozambique however has not listed its definition of urban (Salvatore et al. 2005). In this study, schools were designated urban, semi urban and rural by assessment of the local infrastructure and surroundings. Examination of the differences in RE among urban, semi urban and rural children showed that rural children in Nampula were the least myopic (0.7%), although there was no significant association between locality and URE Pearson Chi Squared 0.91, p = 0.92. Possible reasons for this could include less access to reading material, more time spent outdoors, further to travel to school and requirement for children to labour at harvest time and therefore less access to education (Pan et al. 2012). A summary by He et al. (2009) of international prevalence studies conducted in rural and urban settings shows the urban inhabitants are more likely
to become myopic. Prevalence studies by Paudel et al. (2014) in Vietnam and Padhye et al. (2009) in India also reported a higher rate of myopia in urban schools compared with semi urban and rural schools. Fotouhi et al. (2007) found that locality was a predictor of hyperopia and astigmatism, but not shown to be a predictor of myopia, in primary and high school students in Iran. Hence the expectation would be that a school eye health screening programme in Nampula would detect more children with myopia in urban areas.

In a clinical setting SE alone is not used as a prescribing criteria; spherical and cylindrical components of the RE, along with presenting symptoms and poor functional vision are collectively considered before spectacles are dispensed. Messer et al. (2012) reported that native American students with SE $\leq -1.00$ myopia were twice as likely to wear their spectacles. Holquin et al. (2006) stated that Mexican children prescribed spectacles for a SE -0.50D were the least likely to be wearing them on a return visit by researchers. Interestingly Congdon et al. (2008) investigated which RE cut off would be more likely to ensure South African children were compliant with spectacle wear post screening and they found no relationship between RE cut offs and spectacle wear. This would suggest that children with mild levels of URE who are dispensed spectacles are no less likely to wear them compared to children with significant URE. The research by Congdon et al. (2008) would suggest that children with low levels of URE should be provided with a pair of spectacles. However, spectacle provision for children with mild URE and a good functional level of vision in areas like Nampula, where resources are scarce, would increase the cost of screenings without a definite benefit to the child. When
the estimates of the number of children with significant URE from this study are considered it would seem more beneficial and effective to provide spectacles to those with significant URE and significant vision impairment first.

Although the study sample is biased towards children displaying symptoms of poor eye health or vision, in 2010 no child presented wearing best correction or indeed any spectacles. The study did not investigate the reasons for no spectacle wear. However, Thompson et al. (2015) investigated the barriers to uptake of refractive services in Nampula. The main barriers cited were the cost of spectacles, lack of felt need and distance to travel. Interestingly Loughman et al. (2014) found the spectacle coverage for URE was 0% in adults in Nampula. The 0% spectacle coverage in children and adults means that in Nampula the vast majority of people who need glasses do not have them. Rounding down the most conservative estimate proposed by study 1 (Table 5.4.1) of the number of children with URE including astigmatism there may be approximately 1.3 million children in Mozambique in need of spectacles. Therefore approximately two million people in Mozambique, from young children to the oldest citizens, require, but have no access to spectacles or refractive services. As discussed previously addressing the burden of URE is a cost effective health intervention and would be of benefit to the Mozambican economy (Thompson et al. 2014).

School vision screening is one of the most simple and cost effective health interventions (Baltussen & Smith 2012). In India and Thailand, Lester (2007) and Tengtrisorn (2009) respectively, concluded that school screening was a highly cost-effective method of
addressing URE in school-age children. The education system infrastructure offers an efficient way to detect VI, provide an eye examination and a pair of spectacles or referral pathway to children with ocular pathology. School vision screening in Nampula has the potential to increase the rate of early detection of URE and other eye abnormalities in children and could prove crucial for successful management of these conditions (Logan & Gilmartin 2004).

The screening was logistically challenging and required support from several institutions, provincial directorates and the primary schools themselves. At the time of the study it was necessary to physically visit the directorates and primary schools to seek permission. This usually took several visits to meet the right person. Even with permissions and arrangements occasionally there were communication issues (one day we arrived at the school but it was shut for National Women’s Day). There was a very small faculty in University of Lúrio at the time (the optometry programme began in 2009) so Irish optometrists had to travel to Mozambique to assist the screening. At the time there was no glazing machine in University of Lúrio so some optometric equipment and glazed spectacles were brought from Ireland.

5.4.1 Limitations of the study

This study focused on the school children of Nampula and was conducted from early morning to early afternoon with biased sampling of certain classes due to the time of day screening was performed. Many children in Nampula do not attend school therefore this
group is not represented in this data. Children with VI are more likely to be absent or not enrolled in school. School absenteeism and the barriers to enrolment are discussed further in Chapter six. As study 1 contained a targeted sample, inference to the prevalence of URE etc. in the child population of Mozambique is only an estimate.

It was assumed that all the optometrists and optometry students were proficient in the screening tasks given to them. Optometry students had achieved their competencies in VA measurement (University of Lúrio students) and ophthalmoscopy (Dublin Institute of Technology students). With hindsight it would have been useful to conduct a quality assurance pilot study where the results of the NCR and VA measurements for optometrists and vision screening outcomes for students were analysed using intra class correlation for absolute agreement.

McGraw et al. (2000) compared the surrounded optotypes of the Glasgow Acuity Cards to the Bailey – Lovie acuity chart. McGraw et al. (2000) confirmed that the surrounded optotypes accurately detected changed in acuity over time and differences in acuity between each eye, which are important traits for amblyopia detection. This evidence suggests that a crowded illiterate E logMAR chart ought to be used for further vision screening.

External eye health assessment and ophthalmoscopy were performed on all but two children. The researcher did distribute trachoma grading material in addition to providing
laminated grading charts at the screenings. However, it was difficult to conclude the exact cause of the anterior segment disease from the results. This was mainly due to the broad classification options given to the examiner. Perhaps lack of experience with diagnosing trachoma and vitamin D deficiency may have also been a barrier to specific reporting. In addition examiners did not have access to a slit lamp biomicroscope which is the gold standard for anterior eye assessment and may have aided more specific diagnosis.

Cover test was performed on every child in 2010. In 2012, a decision was made only to perform cover test if an obvious strabismus was present. Cover test should be part of an eye health screening protocol to detect strabismus. This decision was based on time restraints; priority was given to URE which was easily treatable. It was estimated that vision screening and NCR may detect strabismus. Naidoo et al. (2003) found a prevalence of strabismus at near and distance fixation to be present in 1.3% and 1.1% of children respectively. Strabismus found in study 1 (0.7%) is likely to be an underestimate.

Children with anterior or posterior ocular pathology were referred to Nampula Central Hospital. No outcome data was gathered for the referred children. It would have been useful to definitively classify cases of trachoma and vitamin A deficiency. Epidemics of these diseases have public health and eye care planning implications. A recommendation for school eye health screening programmes is that screeners be trained in identifying and grading the signs of trachoma and vitamin A deficiency. In addition it would be useful to
follow up the suspected cases of glaucoma as diagnosis must be confirmed by an ophthalmologist. Future studies could include a follow up visit to the school to ascertain if children wear the spectacles prescribed and provided as occurred in the Tanzania study of secondary school students (Odedra et al. 2008) and to check if children attended the ophthalmologist for further investigation. Future studies could contribute to the identification of myopic risk factors by including a questionnaire on parental education, time spent at near tasks, familial history of myopia, socioeconomic status (Naidoo et al. 2003).

NCR was the objective refraction technique used in this study for several reasons. NCR is reasonably accurate and requires little cooperation from the child (Ying et al. 2011). This is important as the optometrists performing the retinoscopy did not speak the same language as the children being examined. NCR has several advantages for this vision screening study including no side effects or adverse reactions. In this vision screening environment efficient, quick non-invasive screening techniques such as NCR are preferred as it allows more children to be screened in less time, is less expensive and requires fewer resources (Naidoo et al. 2003, Williams 2008, Paudel et al. 2014). No autorefractor was available to the study team. Children with under corrected or uncorrected hyperopia and active accommodation can use their accommodative facility to overcome their hyperopia. NCR performed on these children could potentially overestimate myopia and underestimate hyperopia.
Cycloplegic drugs temporarily paralyse the ciliary muscle to aid assessment of the actual RE present. Performing retinoscopy after the insertion of cycloplegic drugs eliminates accommodative spasm (revealing latent hyperopia) and allows the eyecare professional to disregard pseudomyopia (Luo et al. 2006). 1% cyclopentolate hydrochloride is the most common cycloplegic drug used for cycloplegic eye examinations. The following were the rationales for not using 1% cyclopentolate hydrochloride in this study:

- 1% cyclopentolate hydrochloride was not available in University of Lúrio at the time of this study. The logistics of importing and storing 1% cyclopentolate hydrochloride was not manageable for this study. The importation of health consumables into Mozambique is a lengthy process (up to 2 years), during which time the drug may not be stored at a cool temperature (8 - 27C) (MedicineNet 2014).

- At the time of this optometry led study in Nampula, there was no regulation around topical administration of drugs to the eye by optometrists as optometry is a new cadre and not regulated.

- Cycloplegia bears a very small risk of acute angle-closure glaucoma (Lachkar & Bouassida 2007). As access to eye care is limited in Nampula an acute glaucoma attack may not be treated as quickly as it would in developing countries and may lead to permanent vision loss.

Further work to verify the NCR results using a cycloplegic refraction method was not possible but would have benefited the study. CRet would be the most practical method in
the absence of an autorefractor. Assessing the intra class correlation coefficient between vision screeners and optometrists who performed retinoscopy would have been useful. The specificity and sensitivity of NCR could have been tested by comparing it to CRet results using ROC curves (O’ Donoghue 2012).
5.5 Conclusion

This study was the first optometry led school eye health screening, supported by the Ministry of Health and Education, carried out in Nampula, Mozambique. This optometry led screening was a quick and feasible way of detecting URE, VI and ocular abnormalities among the school children in Nampula. NCR and ophthalmoscopy carried out by optometrists is the method recommended by this study to detect URE and ocular anomalies in school eye health screenings in Nampula.

This study is the first to examine URE, as determined by NCR, in school children in Mozambique. Using the lowest URE values from both the category 1 (RESC) and category 2 approximately 92,000 children in Nampula and 585,000 children in Mozambique potentially have myopia and hyperopia. Gender, age and location of school had no effect on presence of URE in this targeted cohort.

In light of the limited eye care human resources in Nampula this study assessed vision screening as a tool for detecting URE. NCR conducted by optometrists detected far more cases of hyperopia compared with vision screening. Vision screening did not detect many cases of ocular abnormality.

Where resources do not allow for an optometry led eye health screening, this study recommends that the following initiatives be introduced (listed in order of resources required):
1. Vision screening is conducted monocularly using a one line logMAR 0.3 crowded Illiterate E screening chart. Priority children for screening include those at entry (age 5-7 years) and exit grades (age 10 - 12 years), siblings of screening fails, self-reporting children, children with obvious ocular abnormality.

2. Optometrists or skilled ophthalmic technicians re-examine the children who fail the vision screening to detect URE and ocular abnormality.

3. Optometrists or skilled ophthalmic technicians visit classrooms to case find children with obvious ocular abnormality.

4. Optometrists or skilled ophthalmic technicians re-examine a random sample of the children who pass the vision screening to detect false positives.

If URE is detected, an eye examination should be performed in the school with spectacles provided as soon as possible (International Agency for the Prevention of Blindness 2009). These aspects of screening lead to a higher rate of eye examinations performed among screening fails. Bringing primary eye care personnel and service into the schools helps to align screening with the wider school health programme.

Further research ought to be conducted to verify if near vision screening would detect more cases of hyperopia, in addition to distance vision screening in the Nampula school setting. Perhaps feasibility of lay health workers or teachers conducting retinoscopy and ophthalmoscopy ought to be carried out. The role of smartphone technology in school screening in Nampula ought to be assessed.
As a result of the ocular abnormalities detected in this study, it is recommended that children, teachers, parents and community leaders in Nampula be educated on prevention and treatment of eye disease and infection. Further work was carried out in the second study to determine the barriers to CEH in Nampula.

Although there was a low prevalence of myopia, hyperopia and astigmatism, no child presenting with URE or VI was wearing spectacles. It is important to note the sheer magnitude of URE prevalence in Mozambique. Even a small prevalence of URE means that a large number of children are experiencing life today with reduced vision. Child vision and eye health screening is a challenging but essential step in the plan to eliminate URE by 2020.

This chapter focussed on an optometry led, optometry implemented school eye health study. As discussed in Chapter two eye care human resources are limited in Mozambique. There are currently not enough eye care personnel in Mozambique to screen and detect children with VI, URE and other avoidable ocular conditions. Indeed school screenings alone will not detect all children with poor vision and eye health, as many children are not at school. With this in mind the following chapter explores factors that influence CEH in schools and the community in Nampula, Mozambique. Local stakeholders in CEH are identified and various aspects of implementation of CEH programmes are investigated. A pilot teacher led vision screening was conducted in order to ascertain if the vision screening chart was as effective when used by personnel without an optometry background.
Abstract

Purpose:
This study aims to trial teacher vision screening in three primary schools and to gain an understanding of the complex local challenges and considerations that are likely to influence CEH screening by teachers in Nampula.

Methods:
Teachers were recruited to screen school children’s vision during the school screening in 2012. Qualitative data was captured using purposive sampling of CEH stakeholders across different operation levels in the Nampula education and health service.

Results:
22 teachers and 8 optometry students screened 180 children for vision impairment.
Teachers and optometry students identified all 4 (100%) myopes and 5 (75%) hyperopes.
Teachers accurately identified 9 children with URE (sensitivity 38%) compared with 12 children accurately identified with URE (sensitivity 50%) by the optometry students.
Child and teacher absenteeism, lack of literate role model in the family and the cost of education are barriers to teacher screening.

Conclusion:
Teachers had poor vision screening results for hyperopia (38%, sensitivity). A CEH intervention in Nampula should include NCR in order to detect hyperopes. A strong community based element to primary eye care is needed in Nampula.
6.1 Introduction

Access to eye care among the 2.1 million children in Nampula or among the 11.34 million children aged 4 – 15 years in Mozambique is very limited (Garrido 2007). In study 1, it was estimated that over 1 million children in Mozambique have myopia or hyperopia. Study 1 estimated that at least 100,000 of the two million children living in Nampula have URE. In study 1 and in the Nampula RARE study (Loughman et al. 2015) spectacle coverage was 0%, which suggests that children who have VI are not wearing spectacles or receiving treatment. This finding was supported by the data from study 1, which found a large number of children with URE and ocular abnormality among the cohort examined who had not received spectacles or treatment. The available eye health services in Nampula are discussed in Chapter two.

Planning and implementing the CEH screening studies was costly (optometrists mainly travelled from Ireland) and logistically challenging. The unmet demand for eye health services suggests a local, sustainable, more cost effective way of detecting children with poor eye health is needed for Nampula. With the University of Lúrio optometry programme established in 2008, it was envisaged that local optometrists would play an important role in primary eye care, including school eye health in the future. School eye health programmes in other countries have been shown to be a cost effective way to detect, prevent and treat children with VI (Baltussen & Smith 2012).
Already working within schools and the education system, teachers are ideally placed to initiate vision and eye health screening for children. This study builds on the findings from the CEH school vision and eye health screening conducted in study 1. School children with VI were detected in the pilot teacher vision screening study carried out, but not all children in Mozambique attend school (Fox et al. 2012). This study identifies some of the local factors affecting CEH and challenges to teacher CEH screening in order to better understand and recommend how to detect children with URE and ocular pathology. The determination of such considerations will be useful for groups concerned with providing eye health services to children in Nampula and in other provinces in Mozambique.

6.1.1 Aims and objectives

The aim of this study was to trial teacher vision screening, while gaining an understanding of local challenges and considerations that are likely to influence teacher vision screening and CEH in schools and communities in Nampula province.

6.2 Methods

6.2.1 Setting

The teacher vision screening took place in 2012. The setting for this was described in study 1. The qualitative study took place in various locations in Nampula city from 2010 to 2012.
6.2.2 Approach

This study had a mixed methods approach. Grounded theory, as first outlined by Glaser & Strauss (1967) was employed to gather qualitative data which was analysed in addition to quantitative pilot teacher vision screening data.

During the eye health screening in 2012, described in study 1, 22 teachers were invited to use the 0.3 logMAR screening chart (Figure 5.3.9) to screen children’s vision monocularly using the methodology and pass/fail criteria discussed in Chapter five. Once the children were screened by the teachers, they then underwent the full screening protocol as outlined in Section 5.2 including having visions screened by the optometry student team. Both the selection of students and the sequence of vision assessment by teachers or optometry students were randomised. The outcomes of the teacher vision screening and optometry student vision screening were then analysed.

Grounded theory was an appropriate methodology for this study because it allowed for the investigation of a range of qualitative data with freedom for the research to evolve over time as concepts developed (Strauss & Corbin 1990). In addition it offered an outline for data analysis in terms of coding and concept identification eventually leading to theory development. Grounded theory also purports that the data is not the result; it is the theory which is developed from the data that is of interest to the researcher (Glaser & Strauss 1967).
6.2.3 Sampling

6.2.3.1 Teacher vision screening

For the pilot teacher vision screening study any teacher present in the school at the time of the screening was invited to participate. In addition these teachers were also screened for presbyopia with ready readers dispensed to them if necessary. Under the supervision of their teaching staff, University of Lúrio optometry students with competency in VA testing also performed vision screening. Sampling of children has been described in Chapter five.

6.2.3.2 Challenges to teacher vision screening

International, national and provincial approaches to child health and education, as identified through the literature review in Chapter four, informed the purposive sampling of key stakeholders in CEH in Nampula. Purposive sampling is the deliberate selection of stakeholders (individuals, groups of individuals and representatives of institutions) because of the important information they bring to the research (Guba 1981). Sequential sampling, specifically theoretical sampling as outlined by Glasser & Strauss (1967) was employed. As such, stakeholders, scientific articles, grey literature and international publications including websites were sampled to define and elaborate the investigation (Teddlie & Yu 2007).
As the data began to inform the investigation the sampling gradually evolved in keeping with the grounded theory methodology. Key governmental, NGDO and local personnel working in the Nampula health and education systems were identified through the course of the study, mainly during interviews. The stakeholders sampled and the operation levels of the institutional representatives interviewed are listed in Table 6.2.1. Once identified, contact was made with the organisation/representative by e-mail, telephone or text or by visiting the organisation’s local office. The nature and aims of the study and the qualitative techniques to be employed for data collection were explained in full, and identified stakeholder personnel were invited to partake in the study. Informed assent was received prior to formal inclusion in the study and anonymity for stakeholders granted.
Table 6.2.1: Stakeholders identified, their role and interview type

<table>
<thead>
<tr>
<th>Specialist Area</th>
<th>Stakeholder Profile</th>
<th>Data Capture Method</th>
<th>Gender &amp; Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community &amp; Social</td>
<td>NGDO country coordinator</td>
<td>(a) &amp; (b)</td>
<td>(1 M)</td>
</tr>
<tr>
<td></td>
<td>Portuguese NGDO project manager and representative</td>
<td>(a)</td>
<td>(1 M, 1 F)</td>
</tr>
<tr>
<td></td>
<td>Community based volunteer optometrist</td>
<td>(b)</td>
<td>(1 F)</td>
</tr>
<tr>
<td></td>
<td>Community based missionary priest and nun</td>
<td>(b)</td>
<td>(1 M, 1 F)</td>
</tr>
<tr>
<td>Education</td>
<td>Principal at 3 schools (urban, semi-urban, rural)</td>
<td>(a)</td>
<td>(2M, 1 F)</td>
</tr>
<tr>
<td></td>
<td>Teacher focus groups at 2 schools (urban, semi-urban, rural)</td>
<td>(c)</td>
<td>(M &amp; F)</td>
</tr>
<tr>
<td></td>
<td>Marrere teacher training institute (deputy director)</td>
<td>(a)</td>
<td>(1 F)</td>
</tr>
<tr>
<td></td>
<td>Primary teaching institute (director)</td>
<td>(a)</td>
<td>(1 M)</td>
</tr>
<tr>
<td></td>
<td>Lecturer in education university</td>
<td>(a)</td>
<td>(1 M)</td>
</tr>
<tr>
<td></td>
<td>Deputy provincial director of education in Nampula</td>
<td>(a)</td>
<td>(1 M)</td>
</tr>
<tr>
<td></td>
<td>Development specialist for bilateral aid donor</td>
<td>(a)</td>
<td>(1 F)</td>
</tr>
<tr>
<td>Health</td>
<td>Officer at the Ministry of Health with links to some youth projects</td>
<td>(a)</td>
<td>(1 F)</td>
</tr>
</tbody>
</table>

(a) Semi Structured Interview; (b) Questionnaire; (c) Focus Group Discussion; Male (M); Female (F); Non-Governmental Development Organisation (NGDO).
6.2.4 Data triangulation

Data triangulation is the use of several sources to gain an insight into certain phenomena thus reducing bias in a sample (Guba 1981). Data triangulation was utilised in order to fully investigate the concepts emerging from the data collection. Participants working in several operation levels in the education system (from teachers to provincial directors) acting within (e.g. teachers) and alongside the government (e.g. NGDO representatives) were interviewed to substantiate emerging concepts.

6.2.5 Ethics

A letter explaining the study was delivered to the following authorities and permission granted by them to carry out the vision screening: University of Lúrio, the Provincial Departments for Health and Education in Nampula, the head of ophthalmology in Nampula Central Hospital and the school principals. A translated example of the letter is included in Appendix 6.1. After full verbal explanation of the study to the teachers, fully informed assent was obtained. After full verbal explanation of the eye examination by the Mozambican optometry student, fully informed assent was obtained from participating children. At any time children and teachers could opt out of the study. Ethics approval was granted in 2010 from the Dublin Institute of Technology Ethics Committee.
6.2.6 Data collection and analysis

The principal investigator (A.P.) recorded the teacher vision screening results on the screening record form (see Appendix 6.1). Forms were reviewed for accuracy and completeness in the field by the principal investigator. Data input and storage is outlined in Chapter five.

A literature review was conducted, throughout the study, in order to define key international principles of relevance to child health and education strategies and policies for the developing world (Gilbert 2011, World Bank 2012, WHO 2006). Where possible the literature included was of high scientific quality. Where no suitable research was available or appropriate, evidence was included from other sources, including theoretical and conceptual research, deemed to be of high quality in the form of specialist knowledge, websites and non-scientific online publications. Judgement on inclusion was reached based on various principles, including conceptual framing, openness, transparency, appropriateness and rigour, validity, reliability and cogency. National data on the health, education and socio economic status of people of Nampula and Mozambique was sourced from the 2007 Census for Nampula (National Institute of Statistics 2007), data published by World Bank (2013a) and UNICEF (2016). In order to gather background information on NGDOs and Mozambican Government Departments and Institutions working in Nampula, websites were accessed (e.g. Ministry of Education (2013a), UNICEF (2016)). A mixed-methods approach was used to address the study objectives and as a further attempt to reduce bias. The approaches included face to face
semi-structured interviews, teacher focus group discussions, electronic questionnaires, and hand written notes gathered in the field.

Stakeholder semi structured interviews were conducted to explore the challenges children in Nampula may face in attaining education and accessing CEH services. Semi structured interviews were used because the researcher could only interview the participants once so essential questions were asked along with questions shaped by the stakeholder (Bernard 1998). In addition the stakeholders did not have the same experiences, opinions or vocabulary around the considerations so a structured interview with each participant answering the same questions would not have allowed for the capture of diverse opinions (Bernard 1998). Where relevant, questions were tailored for the individual or organisation’s level of influence or involvement in CEH. As such local subthemes were explored with locally active stakeholders (e.g. nun and priest) whereas broader national themes were discussed with the development specialist for a bilateral aid donor.

In preparation for each interview the aims of the interview were identified, and a varying number of specific closed and open-ended questions relevant to the stakeholder were defined. An example is given in Appendix 6.2. Owing to the flexible nature of the semi structured interviews, any other important topics or considerations suggested by the interviewee during the course of the interview were also explored using open-ended questions e.g. “Can you give me more information on this service?”
Interviews took place in schools (teachers and principals), in representatives’ offices or in neutral locations. Interviews were conducted through English or in Portuguese with the assistance of a translator. The interviews were either audio recorded or handwritten notes were taken. Audio recordings were transcribed verbatim using Microsoft Word. Focus groups took place in schools through Portuguese with the assistance of a translator and were audio-recorded. Where notes were taken during interviews every attempt was made for comprehensive note capture of the full response (Wolfinger 2002). Detailed transcription of field notes occurred as soon as possible after the interview using Microsoft Word. Field notes were organised temporally (from what happened first to what happened last) to trigger the researcher’s cognitive memory of other sequential events (Wolfinger 2002).

During data collection coding gaps in the information emerged. In order to strengthen the emerging considerations electronic questionnaires were sent to a purposive sample (Table 6.2.1) identified as having experience which would contribute to the development of the challenges. A copy of the electronic questionnaire is given in Appendix 6.2. Online information and e-mailed questionnaires were translated from Portuguese using Google translate and subsequently reviewed and amended by a Portuguese speaker.

Transcripts were initially coded line by line. Repeatedly identified concepts were highlighted then revisited until challenges emerged (Strauss & Corbin 1990, Glaser & Strauss 1968, Rowan & Huston 1997, Ryan & Bernard 2003). Although common cross-thematic challenges were identified, for consideration purposes all challenges were
allocated, on the basis of primary relevance, to a single dominant theme only. Bias was guarded against in the coding by making comparisons of initial concepts with other data and checking the researcher’s views against the evidence in the data (Straus & Corbin 1990). Verbatim quotations were extracted as examples to support emerging challenges see Appendix 6.3. As a final stage of analysis, in order to examine the coherence of the challenges, peer debriefing was undertaken through the supervisor’s comments on the drafts of this chapter. In this way the researcher was exposed to testing questions about the emerging challenges which aided the development of the challenges (Guba 1981). Referential adequacy was established, that is, existing publications were reviewed for similar findings to the final field results (Guba 1981). In Section 6.3 of this study, where applicable, references to similar findings in publications are given. An example of sampling, interviewing and analysis for an emergent consideration is given in Table 6.2.2.
Table 6.2.2: Example of sampling and interviewing for an emergent consideration

| Consideration: | A history of a good working relationship between Ministry of Health and the Ministry of Education is important for the success of school health programmes. |
| Interviewees: | Local Stakeholders: Principals and the directors of primary school training colleges; Ministry of Health representative with experience of working with Ministry of Education; deputy provincial director for education in Nampula province. |
| Data Capture: | Stakeholders were questioned about their awareness of any existing links between departments and any health and education projects already running. |
| Analysis: | Transcripts and notes were reviewed to identify information relevant to this theme. |

Steps in the exploration of the links between the Ministry of Health and Education.
6.3 Results and Discussion

The results and discussion are divided into four sections. Initially the efficacy of teachers as vision screeners is ascertained from the results of the teacher screener study in 6.3.1. The result of the qualitative study is discussed in 6.3.2, 6.3.3 and 6.3.4.

6.3.1 Rapid teacher vision screening trial in Nampula

6.3.1.1 Demographic profile

A total of 180 children completed the screening by 22 teachers and 8 optometry students. Of these children 81 (45%) were male and 99 (55%) were female as shown in Table 6.3.1.

<table>
<thead>
<tr>
<th>Location of school</th>
<th>Urban</th>
<th>Rural</th>
<th>Semi - Urban</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of children</td>
<td>27 (15%)</td>
<td>84 (46.7%)</td>
<td>69 (38.3%)</td>
<td>180</td>
</tr>
<tr>
<td>Sex of children M/F</td>
<td>13/14</td>
<td>38/46</td>
<td>30/39</td>
<td>81/99 (45%/55%)</td>
</tr>
<tr>
<td>No of teachers</td>
<td>4 (18.2%)</td>
<td>6 (27.3%)</td>
<td>12 (54.6%)</td>
<td>22</td>
</tr>
</tbody>
</table>

The number and percentage of children and teachers involved in the teacher vision screening from each school is shown. The majority of children (46.7%) who took part in this study were from the rural school. The majority of teachers (54.6%) were from the semi - urban school.
The age range was 4 - 17 years of age and the mean age was 10.51 ± 2.75 years. Figure 6.3.1 shows the age distribution of the participating children. The majority of children (51%) were in the 9 - 12 years age bracket; approximately 94% were aged between 5 and 14 inclusive.

Figure 6.3.1: Distribution of teacher vision screening participants by age

The age profile of the children who participated in study 2 with the percentage of total participants above the corresponding bar.

The average number of children screened by each teacher was 8 (range 1 - 27) as illustrated in Figure 6.3.2.
Figure 6.3.2: Children screened by each teacher expressed as a percentage of total children screened

Pie chart shows % of children screened by each teacher. Each teacher screened from 1 - 15% of children.
6.3.1.2 Outcome of vision screening by teachers and optometry students

Table 6.3.2 shows that teachers failed more children on the vision screening test compared to the optometry students. Overall teachers identified 20.6% of the sample as having VI whereas the optometry students identified 12.2% of children to have VI.

Table 6.3.2: Number of vision screening fails as detected by teachers and optometry students

<table>
<thead>
<tr>
<th></th>
<th>Visual Acuity worse than 0.32 logMAR (&lt; 6/12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Eyes</td>
</tr>
<tr>
<td>Teachers</td>
<td>24 (13.3%)</td>
</tr>
<tr>
<td>Optometry Students</td>
<td>15 (8.3%)</td>
</tr>
</tbody>
</table>

The % values given represent the proportion of eyes that failed the vision screening out of the total number of eyes screened. Teachers have a higher number of fails compared to the optometry students. Fail: failing to see four or more letters on the 0.3 logMAR line or equivalent line on the VA chart.

6.3.1.3 Distribution of URE in relation to the VI detected by teachers and optometry students

The vision screening outcome was assessed in relation to the URE value for the children as detected by NCR using category 2 (Myopia ≤ -1.00D, Hyperopia > +1.50D and Astigmatism > -0.75D). Among this targeted cohort, 24 (13%) children screened by
teachers had URE as shown in Table 6.3.3. Teachers detected 9/24 (37.5%) and optometry students detected 12/24 (50%) of the children with URE. Both teachers and optometry students detected all the myopic children. Teachers detected 5/7 (71.43%) cases of astigmatism compared with 4/7 (57.14%) detected by optometry students.

Table 6.3.3: Distribution of participants by uncorrected refractive error and outcome of vision screening by teachers and optometry students

<table>
<thead>
<tr>
<th>Vision Screening outcome</th>
<th>Myopia number (%)</th>
<th>Emmetropia number (%)</th>
<th>Hyperopia number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail</td>
<td>4 (100)</td>
<td>28 (82)</td>
<td>5 (75)</td>
</tr>
<tr>
<td>Pass</td>
<td>0 (0)</td>
<td>128 (18)</td>
<td>15 (25)</td>
</tr>
<tr>
<td>Optometry Students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail</td>
<td>4 (100)</td>
<td>10 (6.4)</td>
<td>8 (40)</td>
</tr>
<tr>
<td>Pass</td>
<td>0 (0)</td>
<td>146 (93.6)</td>
<td>12 (60)</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>156</td>
<td>20</td>
</tr>
</tbody>
</table>

The vision screening outcome of children and the presence of uncorrected refractive error as defined by category 2 (Myopia ≤ -1.00D and Hyperopia > +1.50D).

6.3.1.4 Specificity and sensitivity of vision screening by teachers and optometry students

Overall optometry students were more sensitive and specific screeners; they correctly identified more children with URE and correctly identified more children without URE. Teachers and optometry students showed very high sensitivity (100%) and specificity.
(81%, 90% respectively) for myopia detection (Table 6.3.4). Teachers and optometry students showed high specificity for hyperopia (80%, 91% respectively). The sensitivity of both groups for the detection of hyperopia using the 0.3 illiterate E logMAR chart is very low (25%, 40% respectively).

Table 6.3.4: Sensitivity and specificity of teachers and optometry students for the detection of uncorrected refractive error

<table>
<thead>
<tr>
<th>Screener</th>
<th>Myopia</th>
<th>Hyperopia</th>
<th>Uncorrected Refractive Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity (%)</td>
<td>Specificity (%)</td>
<td>Sensitivity (%)</td>
</tr>
<tr>
<td>Teacher</td>
<td>100</td>
<td>81</td>
<td>25</td>
</tr>
<tr>
<td>Optometry Student</td>
<td>100</td>
<td>90</td>
<td>40</td>
</tr>
</tbody>
</table>

Teachers and optometry students detected URE as defined by category 2 (myopia, SE ≤ -1.00D; hyperopia, SE > +1.50D) using the 0.3 Illiterate E logMAR Chart. n = 180 The sensitivity and specificity for each screener group at detecting URE (myopia, SE ≤ -1.00D; hyperopia, SE > +1.50D) is shown.
6.3.1.5 Discussion

Study 2 indicated that optometry students were more accurate vision screeners than teachers. It was established in study 1 that distance vision screening charts cannot be relied upon to detect all cases of hyperopia. In study 2 it is clear that teachers using the screening chart will detect even less hyperopia than optometry students.

Sharma et al. (2012) reviewed school screening internationally and deduced that teachers are well placed and ideal vision screeners. However the success of teacher vision screening was dependent on the setting and the support they received. Teachers were reported to have a high sensitivity in a study in China (90%) (Sharma et al 2008) and Tanzania (80%) (Wedner et al. 2000). It is likely that teachers have sufficient accuracy in vision screening for older children and in populations where myopia is more prevalent like in China. Study 2 demonstrates that in Mozambique where hyperopia is expected to be more prevalent than myopia teachers were not adequate vision screeners. In addition teachers had a lower URE specificity (82%) which means less efficient screening with more false positives who are not in need of spectacles identified. It is important to point out that optometry students also performed poorly on hyperopia detection. This reinforces the conclusion from study 1 that NCR should be carried out in addition to vision screening.
6.3.2 Barriers to school vision screening in Nampula

Study 1 identified several school children with URE through optometry led school eye health screening. Study 2 examined the effectiveness and feasibility of teacher led school vision screening. Several barriers to teacher vision screening were identified by CEH stakeholders as outlined in Table 6.3.5. Case finding is the term given to detecting children in the population with VI, URE or ocular abnormality. Systemic barriers come from within the educational system (e.g. absenteeism of both teachers and students).

Table 6.3.5: Barriers to school vision screening in Nampula

<table>
<thead>
<tr>
<th>Barriers to teacher vision screening</th>
<th>Examples of specific challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty case finding in schools and the community</td>
<td>Systemic barriers prevent children from enrolling, attending or staying in school</td>
</tr>
<tr>
<td></td>
<td>Family, community &amp; social factors keep the child away from school</td>
</tr>
<tr>
<td>Already overburdened teachers as case finders</td>
<td>Limited current eye health services for children</td>
</tr>
<tr>
<td></td>
<td>Teacher attrition and absenteeism is high</td>
</tr>
</tbody>
</table>

*Main barriers to school vision screening as outlined by CEH stakeholders interviewed in Nampula.*
6.3.2.1 Barriers to case finding in schools and communities

Teachers and the research team identified children in school with URE and ocular abnormality. Not all children in Nampula attend school (Fox et al. 2012). In order to identify children with poor CEH who may not attend school, this study attempted to understand the reasons why children were not at school. It built a profile of the children with poor eye health who do not attend school and suggested potential methods of effective and efficient case finding among the children of Nampula.

From 2008 – 2012 the average percentage of students registered in the initial year of primary school who subsequently graduated was 31% female, 33% male (UNESCO Institute of Statistics 2016). School principals reported that there were very few registered students who did not attend school (“attendance rate”). According to UNICEF (2016) the net primary school attendance rate from 2008 - 2012 in Mozambique was 77.2%. In addition, there were children of school going age who never enrolled in school (“out of school”). According to the UNESCO Institute of Statistics (2016), from 2008 - 2012 the average number of children out of primary school in Mozambique was 703,211.

Respondents identified barriers relating to the education system which prevented children from enrolling, attending or staying in school:

“Free” enrolment in primary school in Mozambique was dependent on each child producing a birth certificate. An NGDO representative reported that certificates cost approximately three weeks wages. Also, although the uniform is optional, children felt
marginalised in school if they were not wearing one (Fox et al. 2012). Educational books were another cost incurred by the families. Several interviewees identified a perceived loss of earnings associated with education: children could be child-minding instead of attending school, freeing an adult to work or working themselves (e.g. clothes washing) to earn money for the family. Elders in the family and community were broadly reported by respondents as highly respected, influential and were key decision makers within communities. It was normal practice for children to care for elders, younger siblings, sick or disabled (including blind) relatives or community members as a priority to schooling.

The vast majority of children in Mozambique are taught through Portuguese (Cabinda 2013). In Nampula most children and their parents speak an indigenous language Makua and not Portuguese. Education through a language other than the native tongue has been identified as a major barrier to attending school in post-colonial countries (Benson 2002). In study 1 the language barrier was an issue, local optometry students communicated with the children during the screening. This reinforced the need for local optometrists who speak the dialect of the community.

Respondents identified factors relating to family and community which may have kept children out of school:

Most children and their families live below the poverty line, as outlined in Chapter two (National Institute of Statistics 2007). Complex issues around poverty were identified or observed as challenges to CEH. Some children in schools showed signs of malnutrition
such as bloated stomachs (as a possible side effect of kwashiorkor) (Heikens 2007). Although the number of these children was not reported in the current study, WHO stated that, in 2012, 45% of children in Mozambique suffered from below average height for their age (WHO 2010). Malnutrition causes eye disease such as Vitamin A deficiency and malnourished people are more likely to have health problems and eye infections. Where communicable eye diseases such as trachoma are present in the population, those who are malnourished are most likely to have them. Smith et al. (2007) reported that children in rural Ethiopia with stunted growth were 1.96 times more likely to have trachoma.

Malnutrition or stunting among child may also cause parents to delay school entry as they feel the child is too weak or small to start school (Fox et al. 2012). Therefore malnourished children should be a priority for primary health care screening. Since they are mostly likely not at school, some eye health screening should take place in the community e.g. public health centres.

It was also broadly observed among respondents that in many families there was no “schooled” role model, no understanding about the importance of education and subsequently poor motivation among children to attend school (Beutel 2011, Cree et al. 2012, Fox et al. 2012). One respondent (NGDO representative) stated “The future is a vague concept; they are living day to day, surviving. In this way it must be difficult for them to grasp how important education is for their children’s future when they are not really seeing past each day”.

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The Plan of Action for Orphans and Vulnerable Children 2006-2010 lists 13 different categories of vulnerable children (Government of Mozambique 2005). Respondents also highlighted several vulnerable groups of children that are likely to be outside the education system including disadvantaged children: children living in rural or nomadic communities; street children (children who may have a home and family but are living on the streets the majority of time); sick children; orphans (“orphan” describes children who have lost a mother, father or both parents (UNICEF 2015); girls; children with albinism or birth deformities and disabled children (physical, mental, blindness and deafness).

According to the Ministry of Education in 2012 there was a steady improvement on school enrolment by orphans from the previous years (Ministry of Education 2013a). Fox et al. (2012) stated that orphaned children in Mozambique were “less likely to be enrolled” and had a higher dropout rate than non-orphans. As they are more likely to be out of school, those orphans with VI may be less likely to have a guardian who will get them access to eye care. The World Bank has devised an “Orphan and Vulnerable Children” toolkit (set of guidance documents) which is useful to understand how to ensure these children benefit from CEH initiatives (World Bank 2005). It includes a guide on what background research to conduct to get an indication of the vulnerability of children in the country of interest. This document would assist Nampula CEH planning initiatives to assess the risks to vulnerable children.

No children with physical disabilities apart from albinism were observed in schools on any school visits. According to one principal there was one small school for disabled children in Nampula, but no school for the blind. A principal stated that there was no
extra educational support for these children. One respondent commented that “Children with special needs, such as Down syndrome or any other disorders are kept away from society, from school and from everybody”. This is supported by Lund & Gaigher (2002) who outline a number of personal and societal perceptions of albino children, in South Africa, which may contribute to their marginalisation from society. It has been shown that girls and disabled children have less access to education in Mozambique (Kuper et al. 2015). Benson (2002) summarises some of the possible barriers to girls attending or completing primary school, the main reason identified in that study is that where parents must choose who receives an education, it is perceived that a boy will yield a higher return for the investment. Certainly in study 1, there were fewer older girls screened in the schools. The researcher observed albino children in the schools and several albino adults in the city. Disabled children were observed on the streets begging. Children were seen accompanying disabled and blind adults who were begging. The researcher did not observe any child with Down syndrome or disabled child in the schools.

Kuper et al. (2012) state that the disability rate among a cohort of 6782 children surveyed in Mozambique was 1.8 %, (95% CI [1.4% – 2.1%]). The age adjusted odds ratio for children with VI attending formal education was 4:7 (95% CI [1.0% – 23.3%]), which means that a child with VI was half as likely to attend school compared to a child with good CEH. Interestingly the meta data in the study by Kuper et al. (2012) showed no significant association between disability and poverty.
A review by Watt et al. (2015) stated that children with Down syndrome present with several ocular conditions such as RE, reduced VA, and strabismus. Children with Down syndrome were more likely to have cataracts, blepharitis and keratoconus. A study of people aged 4 - 25 years with oculocutaneous albinism in Malawi (n = 120) stated that all subjects had nystagmus. The majority of this cohort benefitted from refraction which improved vision by an average of 2 lines on the logMAR chart (Schwering et al. 2015). Limited social support pushes children with disabilities further into poverty (UNESCO 2013).

A large majority of the labour force (77%), especially in rural areas, are farm workers (World Bank 2008). A NGDO representative observed that most of the employment in Nampula was agricultural and seasonal. In July, children left school to work as harvest labourers; they returned to school the next January, having missed half an academic year. This would indicate that school health initiatives should be prioritised after January when more children are likely to be in school.

6.3.3 Barriers to teacher vision screening

Teachers in focus group discussions revealed varying levels of confidence in their ability to detect eye problems in children. Teachers suggested, (with agreement from the group) that those with formal third level education qualifications were more confident in their ability to identify students with vision problems than those without such training or qualifications. Several teachers in the group recounted that they had previously identified
students with vision problems and advised their parents to take them to the ophthalmology department of Nampula Central Hospital.

A teacher training lecturer noted that the education profile of teachers in Nampula was complex and non-standardised. Government of Mozambique figures revealed that, of the primary school teachers in Nampula province, 6.9% have no formal training (Ministry of Education 2013a). Ministry of Education (2013a) listed 18 different types of qualifications held by primary school teachers in Nampula. The most qualified teachers have pedagogic third level training (Beutel 2011, UNESCO-International Bureau of Education 2010).

In 2011, in Nampula, the university lecturer observed that there were too many teachers with less than 3 years completed in a pedagogy programme and not enough primary schools for the population. The university lecturer stated that the Ministry of Education were addressing the issue of poor quality teacher training. One solution to this problem was the up-skilling of teachers without qualifications through distance learning and weekend courses. This statement supported evidence captured by Beutel (2011). On passing these modules teachers received a pay increase. The Ministry of Education (2013b) demonstrated its commitment to teacher training with 5193 graduates from Primary Teaching Institutes in 2013 in Mozambique. The level of education of the teachers who participated in study 2 was not investigated. It is likely that a good basic education is a prerequisite for vision screening training.
Teacher absenteeism

Just as there were challenges to children attending schools there were also challenges to teachers going to work. An NGDO project manager, representative and the priest and nun who worked outside of the education and health system reported a high level of teacher attrition and absenteeism (Beutel 2011). A study into education service delivery indicators in Mozambique found that 45% of teachers were not in school during an unannounced visit and a further 11% were at school, but not in the classroom when they were supposed to be teaching (World Bank 2015c). Teacher absenteeism has an impact on teacher vision screening if teachers trained to be vision screeners are absent from schools they may not screen all the children’s vision in a timely manner.

Overcrowding and lack of facilities

“A solitary teacher stands before 70-80 students. Perhaps, there is a blackboard and chalk. The students may have desks, maybe just benches or the floor to sit on. Some may have no classrooms but must sit outside, under a tree” (Harsch 2000).

The current education system infrastructure and human resource challenges are outlined in Chapter three. On observation there was a lack of teaching and learning aids. There were observations in the field of children with almost empty school bags with one copy book. There were no electricity sockets in the rooms, with variable and typically inappropriate lighting. In the rural school some classes were held outdoors, under the trees. Fox et al. (2012) reported that children received one workbook per year so they had
to personally purchase more. This evidence outlines the need for basic, hard wearing easily reproducible vision screening equipment.

Varied teacher training, teacher absenteeism and attrition, overcrowding and poor school facilities all suggest that teachers would not be ideal vision and eye health screeners in Nampula. If the basic education of the teacher is low then they may not understand some of the basic concepts of vision screening. Teachers with a poor record of attendance would struggle to screen all the children in addition to their workload. Teachers in a class with over 55 students may find teaching challenging enough, adding vision screening to their responsibilities may be unachievable.

6.3.4 Local factors affecting child eye health in Nampula

Factors affecting CEH in Nampula which were identified by the respondents are outlined in Table 6.3.6.

*Table 6.3.6: Barriers to child eye health in Nampula*

<table>
<thead>
<tr>
<th>Barriers to CEH</th>
<th>Specific Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local environmental factors affecting CEH</td>
<td>Presence of communicable eye disease</td>
</tr>
<tr>
<td></td>
<td>Poor water, sanitation and hygiene</td>
</tr>
<tr>
<td>Social challenges to awareness and uptake of CEH service</td>
<td>Role of decision makers and primary influencers in a child's health matters</td>
</tr>
<tr>
<td></td>
<td>No national guidance on public education on eye health regarding who should it be aimed at, what should the message be and what should the medium be?</td>
</tr>
</tbody>
</table>

*Main barriers to CEH as outlined by stakeholders interviewed in Nampula.*
6.3.4.1 Local environmental factors affecting child eye health in Nampula

Teachers (in focus group discussions) and principals reported that good hygiene principles were taught to children daily but due to a lack of water and dusty conditions it was difficult for children to keep clean. Several respondents reported that washing hands was not common practice. An NGDO representative reported that there was very little understanding in the community of the link between health and hygiene.

Observations of school facilities revealed deficiencies in normal school furnishings (discussed in Section 6.3.3). Water and sanitary facilities including toilets (no running water, hole in the ground system with bucket of water to flush and no toilet paper) were also observed to be poor. Latrines were not sanitary or private. Unsanitary latrines have a negative effect on girls attending school and increase the transmission of disease (Sperling 2005).

Interviewees commented, and it was observed on visits to neighbourhoods, that families lived surrounded by rubbish. Respondents reported that families used undrinkable water for everything from drinking to cleaning. One respondent said “Sometimes there is no other option – either drink the unclean water or none at all.” Poor access to running water along with poor hygiene and sanitation has health and sanitation implications and leads to spread of disease, including eye disease like trachoma.
It follows that improvement of the environmental factors affecting CEH such as increased access to water, improved hygiene and more sanitation has the potential to reduce trachoma and other eye infection transmission leading to the eventual elimination of the blinding sequelae in the population (Emerson et al. 2000). Therefore in order to improve CEH teachers and schools may play a role in the detection of eye infection and public education to reduce the spread of eye infections. Ministry of Health and the International Coalition of Trachoma Control estimated that 12.2 million Mozambicans live in endemic trachoma areas. They jointly launched a 5 year campaign in 2014 to significantly reduce the amount of trachoma in Mozambique by 2019 (International Trachoma Initiative 2014). The initiative includes mass drug administration, provision of equipment and support for surgeries and increasing public education on face and hand washing and improving environment. Many of its activities including working with local partners in water, sanitation and hygiene initiatives will improve CEH for children. Certainly there is potential for eye health screening to be integrated into the mass drug administration.

6.3.4.2 Challenges to awareness and uptake of eye health services

The local community, consisting of on average 50 huts, is a very important social unit in Mozambican culture. It is led by a Chief, whose position is recognised by the Government of Mozambique. The Chief advises the community, solves disputes and represents the community at government meetings. The chief is usually a male and much respected among the community. Respondents reported that families have responsibilities to their communities which are far greater than those in Western society. Research has shown that community members are likely to be consulted on family health decisions and
it has been shown that when an intervention includes the whole community it is more likely to succeed (O'Mara - Eves et al. 2012).

The wider community members, elders and community leaders may play an active role in child health decisions, which may not be very well informed (Schnell et al. 2005). Illiteracy, also discussed in Section 6.3.2, will influence decisions made around seeking eye health services for blind or visually impaired children. Vision screening for influential community members and parents should be considered as a means to encourage parental understanding of VI and improve the vision of the whole family.

Other important community members who may have a role in the health decisions made by parents of children with poor CEH and who should also be engaged in CEH interventions were identified. These included:

- **Traditional healers** (witch doctors/curandeiros). Traditional healers were reported by respondents to be important respected members of the community, often the first port of call for sick community members. Studies in other countries reported very poor outcomes for ocular pathology (e.g. cataract and trachoma) treated by a traditional healer (Ademola-Popoola & Owoeye 2004). But traditional healers were identified as respected members of the community and should be engaged to ameliorate the effectiveness of public health messages as shown by Hoff (1992).

- **Community health workers** who received payment from Ministry of Health and or external support from NGDOs were identified by the Portuguese NGDO
representatives as having a useful role in community health. According to Perry & Zulliger (2012) community health workers are cost effective members of the health work force internationally.

The community leaders and, where present, healers and health activists could provide additional support for CEH interventions. Awareness of interventions and lack of understanding of how interventions can restore sight can also influence uptake of services (Lewallen & Courtright 2001). Sharma et al. (2012) reviewed the reasons for non-compliance of spectacle wear by children in several studies internationally. The main reasons cited were that “glasses harm eyes” and “appearance/teasing”. Whether children actually receive and or wear the prescribed spectacles after screening, or whether parents/teachers understand or accept the importance of their children wearing spectacles will be factors in teacher vision screening design. On dispensing spectacles to two children in the orphanage, the community based optometrist was informed by the principal that she was keeping the spectacles. The Portuguese NGDO representative reported: “The director of the orphanage didn’t understand that spectacles would improve the child’s vision and asked if the child could take drops to help their vision.” The director told the optometrist that the children would only sell the spectacles if they received them. This example highlights that hunger is far more important to the poor than good vision. It also highlights the power adults have in health decisions of children and how their perception of the use of spectacles can be skewed.
Other respondents reported that the perception of spectacle wear in Nampula was positive. NGDO representatives and missionaries, reported that adults and teenagers having and or wearing spectacles in Nampula is perceived as a sign of “beauty”, “adornment”, “wealth” and “intelligence”. This indicates that children may want to wear spectacles which may increase the number of false positives on the vision screening examination. It also infers that if children were dispensed spectacles they would more likely to wear them compared to children in countries where there is a stigma around spectacle wear.

Cost was identified by Thompson et al. (2015) as the main barrier to service uptake among visually impaired adults in Nampula. Therefore cost may also be a main barrier to CEH service uptake in Nampula. On further questioning teachers who referred children to the hospital for eye examinations were unsure of the outcomes of these visits and explained that if spectacles were necessary for these students it was likely that the parents could not afford them as no referred children subsequently wore spectacles at school. A solution to cost as a barrier to service uptake was offered by the Portuguese NGDO who subsidised community health workers to travel with children with a health or vision problem to Nampula Central Hospital or to an optometry clinic. The NGDO would also purchase spectacles where needed. It is not known how many of these children received and subsequently wore spectacles.
6.3.5 Potential for child eye health among existing stakeholder programmes and activities

The international best practice for the integration of eye health programmes into wider school health programmes to maximise the benefits to the local people was discussed in Section 2.4. Significant investment from stakeholders in an overall school health programme would be more efficient than investment in an eye health programme and reduce duplication of efforts and resources (Sightsavers International 2011). Owing to limited resources, other organisations and existing health programmes should be identified and engaged in partnership to share costs, avoid service duplication and thus efficiently and effectively eliminate childhood VI and avoidable blindness (Gilbert & Muhit 2012). This section identifies existing programmes or initiatives which may have the potential to incorporate CEH into their activities.

Studies have shown that school is an ideal place to promote health messages (Stewart-Brown 2006). There are several governmental policies and plans which outline aspects of school health in Mozambique. These include:

- The School Health Programme, created in 2010, which is led by the Ministry of Health and the Ministry of Education. In 2012 a budget was allocated to the school health programme but no planning was in place or strategies existed as to how it should be spent. The bilateral aid development specialist stated “There needs to be more clarity as to who drives school health”. The school health programme is aimed at involving teachers and health technicians in basic health
screening in the areas of nutrition, hygiene, sanitation, vaccinations and reproductive health.


- The School Health Guidance Document (Government of Mozambique 2009) made a minor reference to vision and auditory senses. It outlined whose role it was to check the health of the children and recommended four visits per year to the schools by Ministry of Health general health technicians to monitor children’s health. This may be logistically challenging, there are not many paved roads in Mozambique and some rural schools and communities are at least 12 hours from cities. In addition there is a shortage of mid-level health care workers in Mozambique, as discussed in Chapter three.

Each of the above policies and plans has the potential to integrate CEH e.g. the ophthalmic technician ought to travel to schools with the vaccination team or the general health team in order to screen eye health.

Studies have shown that teachers trained in health promotion are more likely to take part in promotion activities than those who have not received training (Jourdan 2011). The following are suggestions of where promotion of health and CEH could be incorporated into pedagogic and primary school curricula.
1. In teacher training curricula in the institutes ran by the state, private enterprise and NGDOs:

There was no compulsory module on health in the teacher training institutes in 2012. The director of the teacher training institute stated that the Ministry of Health conducted a short one week course during the teacher training programme in 2011. A compulsory accredited module on health incorporating eye health would be ideal.

2. Upskilling/professional development programmes:

As discussed in Section 6.3.2 the Ministry of Education recently recognised the need for an increased emphasis on quality of education rather than quantity of teachers. In response to this shift in policy teacher upskilling programmes, via distance learning or taught courses were implemented throughout the country. Such upskilling programmes may have potential to incorporate health, including eye health training.

3. In the primary school curriculum:

The development specialist for a bilateral aid donor highlighted that the National Education Strategy outlined an interesting aspect of the new curriculum entitled the Local curriculum. This was a blank module of the national primary education curriculum which can be devised at school/provincial level to adapt to a local need (Bonnet 2007). The local curriculum may be a pathway for health and eye health lessons, especially if educators are aware of a local endemic eye condition e.g. trachoma.
Sporadic health links or visits were identified by educational stakeholders in primary schools and primary education training colleges. Examples of these links identified by principals, NGDO representatives and a development specialist for a bilateral aid donor are listed below. Each of these links has the potential to be a conduit for case finding and CEH public education.

**Tetanus vaccination campaigns** were conducted occasionally in Nampula schools by Ministry of Health nurses.

**Biannual child and maternal health weeks** for mothers and children under five years of age included Vitamin A distribution which reached the local communities. Ophthalmic technicians or optometrists could provide CEH screening alongside the drug distribution.

**UNICEF Child Friendly Schools Initiative Angoche, Nampula.** The aim of the programme was to improve the quality of education and it included a basic health teacher training aspect for all teachers which included some eye health information (UNICEF 2010). These schools received health packages which include eye care, vaccinations and dental care for children.

Links between schools and the health department and communities identified by principals, teachers and the development specialist for a bilateral aid donor:

**School, Parent and Community meetings** occurred at the start of the academic year and occasionally during the school year to inform of health initiatives such as tetanus vaccination campaigns. School/community meetings present an opportunity to educate
parents on VI, the importance of eye health, sanitation and the availability of eye examinations and spectacles for those with reduced vision.

School Council – according to the development specialist for a bilateral aid donor every school was supposed to have a school council made up of teachers and parents, who reported school issues to the Provincial Directorate of Education. The aid specialist commented that some school councils worked very well and even had a system of reporting issues via text to the Provincial Directorate. Some worked less well because their structure was complicated with excessive demands on sometimes poorly educated parents. Where school councils work well perhaps they could become involved in the organisation or logistics of school eye health screenings. Perhaps a responsible parent could travel with groups of children to the eye clinic if parents are not available to do so.

Busy Generation (Programa Geracao Biz) - local youth leaders were trained in reproductive health public education and human immunodeficiency virus infection/acquired immune deficiency syndrome public education. They presented to youth groups in their communities about these issues (Hainsworth & Zilhao 2009). Youth leaders could become case finders in the community. Perhaps they could be supplied with a simple vision screening chart to screen youths. Youth leaders could also educate their peers on aspects of CEH.

6.3.6 Limitations of the study

The study did not gather demographic information on the teachers and student vision screeners. It would have been useful to assess if teachers with a certain education level or
gender had better outcomes on the screening task. In addition gathering information on what would motivate teachers to perform vision screening would be useful.

The researcher should have ensured that children were randomly assigned either a teacher or an optometry student first in attempt to eliminate fatigue from the test or improved results from practice.

As in study 1 it was assumed that optometry students were proficient in the screening tasks given to them. With hindsight it would have been useful to conduct a quality assurance pilot study in advance of study 2, where the results from the vision screening outcomes for a small sample of teachers and students were checked against an optometrist’s measurements for the same child using Intra Class Correlation.

The qualitative study gathered information from a small purposive sample of CEH stakeholders in Nampula. Due to limited time it was not possible to meet with families in the community, vulnerable children, community leaders, traditional leaders. Information gathered from these stakeholders in the community may have enhanced the research.
6.4 Conclusion and Recommendations

Teachers were effective vision screeners for myopia using the 0.3 logMAR screening chart. Considering the minimal training received by teachers, this suggests that the simple chart is an easy to use screening tool which is quite accurate at detecting myopia. Teachers can become proficient at using the chart in a matter of minutes. Neither teachers nor optometry students were effective at screening for hyperopia. Hyperopia is the main URE among children in Nampula. Therefore teacher vision screening will not detect all cases of hyperopia or ocular abnormalities. Personnel proficient in NCR and ophthalmoscopy are required to increase the detection rate for hyperopia and ocular abnormalities.

This study used qualitative research in order to investigate beyond the quantitative results of teacher vision screening. Analysis of the qualitative data captured and the pre-existing scientific literature revealed a number of complex factors colluding to reduce the chances of healthy and vulnerable children (including those with VI and blindness), retaining their current vision and eye health in Nampula. These factors included: case finding (child and teacher absenteeism); systemic barriers (cost of “free” education); environmental factors (poor understanding of the importance of hygiene and sanitation) and barriers to service uptake (lack of literate guardian). The overarching challenge to CEH is the all-encompassing circle of poverty which most children in Nampula are born into and may never escape.
A CEH intervention in Nampula must be centred on a school eye health screening programme, involving trained personnel (skilled ophthalmic technicians or optometrists). These eye care personnel should be conversant in the local dialect. The intervention should be co–managed by the Ministry of Health and Education.

A CEH intervention must also include a strong community based programme, if it is to reach the most vulnerable children who are most in need of eye care services. Eye health screening of children in orphanages and in the few schools for disabled children should also be prioritised. Early engagement with teachers, community leaders, parents, community health activists, traditional healers and children themselves is important. Local stakeholders may also be successful at case finding people with VI in the community. Public education around the CEH intervention ought to be culturally sensitive, include information about the intervention, hygiene and VI.

This study highlighted several examples in Nampula of interdepartmental school health initiatives. But there was no full time liaison officer appointed to work with both the Ministry of Education and Ministry of Health. Stakeholder engagement and inclusion is a recommended first step for empowering the community. This study identified stakeholders in eye health, health, education and child welfare working in Nampula. A CEH intervention, in addition to school screening ought to look to integrate into established school and community health initiatives. An example may be to include eye health training in the youth training for Busy Generation. Utilizing established community NGDO s and networks will speed up the implementation and possibly
increase the detection rate of children with poor CEH. By empowering and educating the community, children and teachers, they all become activists for health (Institute of Development Studies 2013). This study investigated the most appropriate people to target for CEH in Nampula. In a society where community members outside the immediate family such as elders, leaders and traditional healers have an influence over whether to treat and how to treat a child’s medical condition, such individuals should be included in the CEH interventions to ensure children access the service.

Further work may include a feasibility study which looks at the cost and potential economic and health benefits of a CEH initiative involving trained personnel such as optometrists or ophthalmic technicians. Planning for a CEH initiative in Nampula should include engagement with local communities and families including influential community members (chiefs and traditional healers); conducting focus discussion groups with a sample of local families; identification and communication with a wider group of NGDO and government stakeholders including those involved in water, sanitation and hygiene groups.

The third study outlined in Chapter seven examined the RE and VI of children attending Irish private practice optometrists. The effect of cycloplegia on the RE found and the method of investigating URE was examined. In addition a pilot study of the long established primary school screening which took place in Irish primary schools was conducted.
Abstract

Purpose:
RE, VI and strabismus were examined in children who presented to private practice optometrists for eye examinations in Ireland, including a cohort who had failed/passed the HSE school vision screening.

Methods:
The study was conducted by 10 optometrists in 9 private practices in 2015. Optometrists performed full cycloplegic (1% cyclopentolate hydrochloride) eye examinations. CAR right eye SE values were analysed for the presence of myopia and hyperopia (SE ≤ -0.50D or ≥ +2.00D) and astigmatism (cylinder ≥ -0.75D).

Results:
109 children ((45.9%) male, (54.1%) female) aged 3-15 years were included in the study. The mean RE was +1.26D ± 2.53D, 95% CI [0.81 – 1.71]. There were 25 myopes, 41 hyperopes, 34 cases of astigmatism and 8 cases of strabismus. Of the 30 children who failed the HSE screening there were 7 (23%) myopes, 11 (34%) hyperopes and 15 (50%) cases of astigmatism and 2 cases of strabismus.

Conclusion:
VI, RE and strabismus were present in this targeted cohort including those children with a fail on HSE screening. Therefore parents of school children are paying for child eye care where there is a clinical necessity and a delay to provision of eye care by the state.
7.1 Introduction

This study involved children who presented to private practice optometrists for eye examinations in the Republic of Ireland. It analysed the VI, RE and strabismus among a targeted cohort of children attending optometrists in an attempt to highlight the need for optometric eye care to be included in the community ophthalmic scheme. A study of this kind has not previously been conducted in Ireland.

As discussed in Chapter four there may be long waiting lists for children to attend the community ophthalmic physician in Ireland. Optometrists are not currently employed by the HSE community ophthalmic scheme.

Due to long waiting lists for ophthalmological assessment, some parents opt to pay to have their children’s eye health assessed in private optometric practices. A pilot study was conducted to investigate if children in this cohort who failed/passed the HSE school screening and those waiting for a recall to the community ophthalmic physician had VI, RE and strabismus.

As discussed in Section 5.4 NCR can underestimate hyperopia and overestimate myopia. Two categories to determine RE were investigated in study 1; however it was not possible to compare the results of NCR with the gold standard CAR. In this Irish study which involved skilled optometrists, the use of the readily available cycloplegic drugs...
and diagnostic equipment, it was possible to examine the relationship between NCR, CAR and the categories outlined in study 1.

7.2 Materials and methods

7.2.1 Setting and participants

The study took place in 9 optometry practices around Ireland from March to July 2015. A total of 113 primary school children were examined. Due to missing information on the records of 4 children, the data from 109 children was used.

Inclusion Criteria

All Caucasian primary school children who presented to the optometry practice for an eye examination were invited to take part in the study.

Exclusion Criteria

Adults were not included in the study.

7.2.2 Participating optometrists

All experienced optometrists with a special interest in paediatric optometry practicing in Ireland were invited to take part in the study. Optometric eye examinations were conducted in 9 private optometry practices by 10 optometrists in 7 counties in the Republic of Ireland. All optometrists had over 7 years’ experience (range 7 - 30 years) except for 1 newly qualified optometrist with excellent grades and proven expertise in
paediatric optometry. Every effort was made to include optometrists from a wide geographical spread. In advance of the study optometrists received the study information pack and study protocol (Appendix 7.1). The researcher visited the optometrist to conduct quality assurance by re-examining three children examined by the optometrist and checking the inter rater variability score. At this visit the study protocol, including equipment use, measurement methods, and correct completion of the eye examination form (shown in Appendix 7.2) was outlined by the principal investigator (A.P.). The auto refractor was calibrated by the researcher at the initial visit. The optometrist then conducted an eye examination in line with the study protocol on children visiting the practice over the next few months.

7.2.3 Optometric examination procedures and instruments

Each child underwent the optometric eye examination protocol outlined in Figure 7.2.1 and in the protocol guidelines (Appendix 7.1). Retinoscopy was carried out at 67cm using a streak retinoscope and a working distance lens +1.50D in front of both eyes. The eye not being examined was blurred. Optometrists performed a quick check of the reflex in the eye not being tested to make sure it was blurred sufficiently. Children were asked to look at a non-accommodative target 3.5 - 6 metres away (distance varied due to room length).

Strabismus was assessed at distance (at least 4 m, using the smallest letter on the logMAR chart that could be seen clearly with each eye) and near (33 cm, using an
appropriately sized fixation target on the Budgie Stick) using the cover/uncover test both unaided and with spectacles if worn.

1 drop of 0.5% proxymetacaine hydrochloride (local anaesthetic) was inserted into each conjunctival sac, followed by 1 drop of 1% cyclopentolate hydrochloride. After 30 minutes the pupils were checked for no reaction to light and that the pupil diameter had increased to 6mm or more.
Figure 7.2.1: Eye examination flowchart

Case history
↓
Presenting &/ uncorrected visual acuity assessment
↓
Binocular vision assessment: Cover test; Motility; Stereopsis; Near point of convergence, Amplitude of accommodation. & Pupil Assessment & Slit lamp biomicroscopy
↓
Non cycloplegic refraction tests: autorefraction, retinoscopy, subjective refraction
↓
Instillation of drops: 1 drop of 0.5% proxymetacaine hydrochloride, 1 drop of 1% cyclopentolate hydrochloride
↓
Cycloplegic refraction tests: autorefraction, retinoscopy, subjective refraction
↓
Ophthalmoscopy
↓
Diagnosis and Conclusion communicated to parent

Flow chart of the test protocol.
7.2.4 Ethics

Ethics approval was granted from the Dublin Institute of Technology Ethics Committee. The study was carried out in compliance with the tenets of the Declaration of Helsinki. All optometrists signed an agreement to adhere to the DIT Child Protection Policy. Before the eye examination, the study was explained and informed consent was obtained from a parent/legal guardian and from the child if aged 10 years or over (see Appendix 7.3).

7.2.5 Data collection and analysis

Data collection

Results were collected on the eye examination form (see Appendix 7.2). Forms were reviewed for accuracy and completeness in the field by the participating optometrist. Optometrists assigned a number to the form which coded the optometrist and the child. A separate password protected file was created to store the names of the participants, together with their unique identity code by the optometrist. Manual data was then forwarded to the research supervisor at DIT. Manual data when not in use was stored in a locked cabinet. Access to the data was restricted to the research team. Data was managed in accordance with the Data Protection Act 1988 and the Data Protection (Amendment) Act 2003.
Initial data entry for the study was carried out using MS Office Excel. The data was anonymised by using an individual code for each participant for data security and confidentiality purposes. The file with the code was kept separate to the anonymised data. The data was then transferred to the statistical package IBM SPSS Version 22 (SPSS Inc., Chicago, Illinois, USA), where error checking including outlier rechecking was carried out prior to statistical analysis. All data files were encrypted and regularly backed up. The data was used for the present study only.

Statistical methods/data analysis

The statistical software package IBM SPSS Version 22.0 (SPSS Inc., Chicago, IL, USA), was used for analysis. The 5% level of statistical significance for hypothesis tests, and 95% confidence intervals for means, proportions and correlation coefficients were used throughout all statistical analyses, without adjustment for multiple testing. Quantitative outcome variables analysed in this study included SE, sphere only, cylinder, MAR VA. The distributions of these variables were checked for normality using the Kolmogorov-Smirnov test, and non-parametric methods (such as the Spearman’s rho test) were used when non-normality was detected. Results for the right and left eyes of each subject were compared using appropriate correlation methods. Subsequent analyses of refractive data were confined to right eyes only (following standard practice in the majority of RE prevalence studies (Junghans & Crewther 2005)). This method of analysis avoids data duplication which can impact on the statistical significance of the results (Newcombe & Duff 1987). Histograms were used for graphical analysis/presentation of quantitative variables.
The SE was calculated using the sphere and cylinder from CAR data, based on the following equation: \( SE = \text{Sphere + Cylinder}/2 \). The number of cases of myopia, hyperopia, and astigmatism was determined using cycloplegic auto refraction (CAR) and the following category 1 definition: myopia, \( SE \leq -0.50 \text{D} \); hyperopia, \( SE \geq +2.00 \text{D} \) and astigmatism was defined as cylinder \( \leq -0.75 \text{D} \). Emmetropia was classified as \( SE > -0.50 \text{D and} < +2.00 \text{D} \).

As defined by WHO (Gilbert & Ellwein 2008), presenting VA was VA with spectacles and unaided VA was unaided vision with no spectacles. LogMAR vision measurements were converted to MAR for mean and standard deviation calculations. Thus avoiding an error in the mean calculation, this would be incurred with the use of log values (Bailey 1988, Bailey & Lovie-Kitchin 2008, Holladay 1997).

Categorical outcome variables analysed in this study included myopia, hyperopia, astigmatism, emmetropia, RE category, strabismus, presenting complaint and previous outcome of HSE examination. Pie charts and bar charts were used for graphical analysis/presentation of categorical variables.
7.3 Results

7.3.1 Demographic profile

A total of 113 Caucasian children completed the eye examination. Due to incomplete data for 4 children 109 children are included in the study. 50 (45.9%) were male and 59 (54.1%) were female.

The age range of the 109 children was 3 - 15 years of age and the mean age was 8.48 ± 2.83 years. Figure 7.3.1 shows the age and gender distribution of the participating children. The majority of children (nearly 90%) were in the 5 - 12 years age bracket; more than 96% were aged between 4 and 13 inclusive. Figure 7.3.1 shows the distribution by gender of the participating children; there are slightly more females in this study.
Figure 7.3.1: Age and gender distribution of the participants

The age profile of the children who participated in this study with the percentage of total participants above the corresponding bar: 18.3% were 5 years old, 26.6% were 10 and 11 years old.

12 optometrists from various private optometry practices around Ireland took part in the study. The response rate was approximately 12/70. The low response rate was due to several optometrists not having an autorefractor. The data from 2 optometrists was incomplete so the results from 10 optometrists are presented here. Figure 7.3.2 shows the locations of the participating optometrists. Figure 7.3.3 gives a breakdown of the percentage of the total children examined by each optometrist. The minimum number of children tested by an optometrist was 5 children and the maximum was 25 children.

After both the optometrist and researcher tested 3 children (in one case only 2 children
were tested) intra class correlation was performed for absolute agreement between measurements as outlined in the methods Section 7.2.3 (see Appendix 7.4.1 for a summary table).

**Figure 7.3.2: Location of the participating optometrists**

Figure 7.3.3: Children screened by each optometrist expressed as a percentage of total children screened

The optometrist identification number is given in the segment in addition to the percentage of children screened. Each segment shows value, percentage of total.
7.3.2 Investigation of refractive error, visual impairment, strabismus and presenting complaint

7.3.2.1 Refractive error

The SE of the CAR was calculated for the 109 children. Right eye SE data was used for analysis in this study because of the strong correlation between right eye and left eye data (in this study, Spearman’s rho $r_s = 0.94$, 95% CI [0.88 - 0.98]). The mean SE for the right eye, as determined by CAR, was $+1.26 \pm 2.53 \text{D}$, 95% CI [0.81 - 1.71]. The distributions of RE expressed in SE for the right eyes are shown in Figure 7.3.4.
**Figure 7.3.4: Distribution of refractive error**

Refractive error expressed as right eye spherical equivalent in children ages 3-15 years old. The black continuous line represents the expected values if the data has a standard normal distribution.

The distribution of RE in Figure 7.3.4 show a very slight negative skewness (data to right of graph) and a positive kurtosis (data peaks centrally). There are some outliers to the SE, with a 5% trimmed mean +1.27D, 95% CI [0.79 - 1.75]. In this study the mean and trimmed mean are very similar so the outliers are included in analysis (Pallant 2013). The
Kolmogorov-Smirnov test for normality showed a significance value of $p = 0.00$, this indicates non normal distribution which is common in larger samples (Pallant 2013).

There was a strong correlation between the right eye SE and right eye sphere only measurements (Spearman’s rho $r_s = 0.99$, 95% CI [0.88 - 0.97]), $p = 0.00$). The SE (+1.26D ± 2.53D, 95% CI [0.81 - 1.71]) rather than sphere only (mean +1.57D ± 2.59D, 95% CI [1.09 - 2.05]) were used for analysis.

There were 25 (22.9%, 95% CI [0.15% – 0.31%]) cases of myopia and 41 (37.62%, 95% CI [0.29% – 0.47%] cases of hyperopia among this targeted cohort, using the CAR measurements and category 1.

7.3.2.2 Visual impairment

VA was measured using logMAR then converted to MAR for analysis. The MAR data for both eyes was used for analysis in this study because of the strong correlation between both eyes and right and left eye data (see Appendix 7.4.2 for values). The mean unaided VA for both eyes was +1.84 MAR ± 2.27, 95% CI [1.33 – 2.34] (approximately 0.26 logMAR). The distributions of unaided VA expressed in MAR for both eyes are shown in Figure 7.3.5. The mean presenting acuity for both eyes, measured for 25 cases was +1.95 MAR ± 3.35, 95% CI [0.56 – 3.32] (approximately 0.29 logMAR). The mean corrected VA was +1.27 MAR ± 0.6, 95% CI [1.12 – 1.34] (approximately 0.1 logMAR). The percentage of uncorrected, presenting, and best-corrected VA of 0.32 logMAR or worse in the better eye was 20.2%, 2.8%, and 3.7%, respectively.
VA expressed as MAR for both eyes, in children aged 3 - 15 years old. The black continuous line represents the expected values if the data has a standard normal distribution.

The distribution of RE in Figure 7.3.5 show a positive skewness (data to left of graph) and a positive kurtosis (data peaks centrally). There are some outliers to the MAR, with a 5% trimmed mean +1.44, 95% CI [1.24 - 1.9]. In this study the mean and trimmed mean are similar (approximately 0.1 logMAR difference) so the outliers are included in
analysis (Pallant 2013). The Kolmogorov-Smirnov test for normality showed a significance value of \( p = 0.00 \), this indicates non normal distribution (Pallant 2013).

### 7.3.2.3 Strabismus

There were 8 (6.8%, 95% CI [2.2% - 11.4%]) cases of strabismus in this targeted cohort. There were 6 cases of esotropia, one case of alternating esotropia and one case of exotropia.

### 7.3.2.4 Presenting complaint

Figure 7.3.6 gives the main reasons reported for children’s attendance for an eye examination among this targeted cohort. 33 (30%) of the 109 children examined had previously undergone HSE screening. 30 failed the screening and 3 passed the screening. Of the children who passed the screening 2 reported headaches and one reported blurred distance vision as their main reason for attending. In addition 10 presented to the optometrist because they were waiting too long for a community ophthalmic physician appointment. A problem with distance vision was the main presenting complaint as well as for a routine check-up with no symptom
Figure 7.3.6: Breakdown of the nature of presenting complaint

Breakdown of the main reason given for presentation for eye examination at private practice. Each segment shows value, percentage.
7.3.3 Classification of refractive error

7.3.3.1 Investigation of categories and objective refraction techniques

The data was further divided into two categories to examine the effect of using the two different RE classifications for different methods of determining RE (as discussed in the Section 7.2.2). The two categories were:

Category 1: myopia, SE ≤ -0.50D; hyperopia, SE ≥ +2.00D

Category 2: myopia, SE ≤ -1.00D; hyperopia, SE > +1.50D

The methods analysed were NCR, CAR and CRet. Figure 7.3.7 demonstrates the numbers of children with RE as defined by each of the 2 categories and measured with the methods outlined above. NCR with category 1 gave the highest estimate of myopia, whereas CRet with category 2 gave the lowest estimate. NCR with category 1 was the only combination to estimate a higher number of myopes compared to hyperopes. All cycloplegic methods and category combinations estimated a higher number of hyperopes than non cycloplegic methods.
Figure 7.3.7: Distribution of refractive error as defined by category 1 and 2 using 3 methods

The breakdown of RE as defined by category 1 and category 2 using various methods of detection RE.

Of note, there is a strong positive correlation between the CAR category 1 and NCR category 2 (Spearman’s rho $r_s = 0.86$, $p = 0.00$). Linear regression was used to predict the CAR and CR score from the NCR score. The following equation was generated: $\text{CAR} = 0.57 + 1.077 \times \text{NCR}$. Thus if $\text{NCR} = +0.5\text{D}$ then $\text{CAR}$ is estimated as $0.57 + 1.077 \times 0.5 = 1.11\text{D}$. The following equation was generated for CR: $\text{CR} = 0.6 + 1.07 \times \text{NCR}$. Thus if $\text{NCR} = +0.5\text{D}$ then $\text{CR}$ is estimated as $0.6 + 1.07 \times 0.5 = 1.14\text{D}$. The regression line fits
the data well for both equations ($r$-sq = 0.93 respectively) so the predicting equation gives reliable estimates of CAR and CR.

All but one myopic case (-0.75D) were detected by the NCR using category 2 when the values were compared to the SE CAR. Of the hyperopic cases not detected by NCR using category 2, 1 had significant hyperopia (+3.75D) 2 had +2.00D hyperopia and 3 children had +2.12D.

**Astigmatism**

There was a strong positive correlation between the cylinder value in the right and left eyes measured with CAR (Spearman’s rho $r_s = 0.59$, 95% CI [0.44 - 0.73]). Only cylinder data from right eyes was used for the refractive class analysis. The astigmatism measured, using the cylindrical component of the cycloplegic autorefraction prescription for the right eye of the sample data, had a mean of -0.60D ± 0.75 (SD), 95% CI [-0.76 - -0.48]. There were 34 (31.2%, 95% CI [22.5% - 39.9%]) cases of astigmatism (cylinder ≤ -0.75D) using CAR and category 1.
7.3.3.2 Measurement agreement

In this study, as shown in Table 7.3.1 all cycloplegic examinations were more hyperopic than non cycloplegic examinations, Wilcoxon Signed Rank Test, p = 0.00 (see Appendix 7.4.3 for table). Of note the NCR was more myopic than the CAR (Wilcoxon Signed Ranks Test, z = -7.51, p = 0.00). Also the NCR was more myopic than the CRet (Wilcoxon Signed Ranks Test, z = -7.89, p = 0.00).

Table 7.3.1: Means spherical equivalent (right eye) for three refractive tests

<table>
<thead>
<tr>
<th>Refractive Test</th>
<th>SE mean ± SD</th>
<th>[95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCR</td>
<td>+0.68 ± 2.32</td>
<td>[0.21 – 1.13]</td>
</tr>
<tr>
<td>CRet</td>
<td>+1.32 ± 2.53</td>
<td>[0.81 – 1.81]</td>
</tr>
<tr>
<td>CAR</td>
<td>+1.23 ± 2.54</td>
<td>[0.79 – 1.81]</td>
</tr>
</tbody>
</table>

SE – Spherical Equivalent; NCR – non cycloplegic autorefraction; CRet –cycloplegic retinoscopy; CAR –cycloplegic autorefraction;

In this sample of 109 children there was a strong positive correlation between the SE NCR value in the right eye and the CAR value in the right eye (Spearman’s rho $r_s = 0.91$, 95% CI [0.84 – 0.95], p = 0.00). The difference in the NCR and CAR SE mean values was +0.55 ± 0.22 (with CAR more positive).
Table 7.3.2: Spearman’s rho correlations for spherical equivalent (right eye) for each refractive test

<table>
<thead>
<tr>
<th></th>
<th>NCAR</th>
<th>NCR</th>
<th>NCSR</th>
<th>CAR</th>
<th>CRet</th>
<th>Cycloplegic Subjective refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAR</td>
<td>-</td>
<td>0.84**</td>
<td>0.82**</td>
<td>0.80**</td>
<td>0.77**</td>
<td>0.77**</td>
</tr>
<tr>
<td>NCR</td>
<td>0.84**</td>
<td>-</td>
<td>0.95**</td>
<td>0.91**</td>
<td>0.92**</td>
<td>0.91**</td>
</tr>
<tr>
<td>NCSR</td>
<td>0.82**</td>
<td>0.95**</td>
<td>-</td>
<td>0.90**</td>
<td>0.91**</td>
<td>0.91**</td>
</tr>
<tr>
<td>CAR</td>
<td>0.80**</td>
<td>0.91**</td>
<td>0.90**</td>
<td>-</td>
<td>0.97**</td>
<td>0.97**</td>
</tr>
<tr>
<td>CRet</td>
<td>0.77**</td>
<td>0.92**</td>
<td>0.91**</td>
<td>0.97**</td>
<td>-</td>
<td>0.96**</td>
</tr>
<tr>
<td>Cycloplegic subjective refraction</td>
<td>0.77**</td>
<td>0.91**</td>
<td>0.91**</td>
<td>0.97**</td>
<td>0.96**</td>
<td>-</td>
</tr>
</tbody>
</table>

All tests showed strong correlation with Spearman’s rho using the SE of the right eye in the following tests: (N)CAR - (non) cycloplegic autorefraction; NCR - non cycloplegic retinoscopy; CRet - cycloplegic retinoscopy; NCSR - non cycloplegic subjective refraction; **p = 0.00 (2 tailed)

In this cohort there was a very strong correlation between all measurements as shown in Table 7.3.2. In private optometry practice the cycloplegic subjective refraction is the most relied upon measurement to determine RE. CAR correlates best to cycloplegic subjective refraction. NCAR has the poorest correlation to the each of the cycloplegic results (average 0.78) whereas NCR has a very strong correlation (average 0.91) to all of the cycloplegic tests.
**Astigmatism**

There were 33 (30.3%, 95% CI [21.7% - 38.9%]) cases of astigmatism with NCR. There were 32 (29.4%, 95% CI [20.8% - 38%]) cases with CRet. In this sample of 109 children there was a strong positive correlation between the astigmatism measured with NCR and CAR, NCR and CRet (Spearman’s rho \( r_s = 0.66 \), 95% CI [0.52 - 0.77], \( r_s = 0.79 \), 95% CI [0.69 - 0.88], \( p = 0.00 \)) respectively. When compared to the NCR, the CAR detected slightly more astigmatism (Wilcoxon Signed Ranks Test, \( z = -2.05, p = 0.04 \)). As expected there was no significant difference in the astigmatism between the NCR and CRet (Wilcoxon Signed Ranks Test, \( z = -0.67, p = 0.53 \)). The difference between the NCR and CAR astigmatism mean values was \(-0.07 \pm 0.35\) (the CAR was very slightly more negative).

### 7.3.4 Pilot study to examine the children with a fail on HSE school screening

#### 7.3.4.1 Outcome of HSE school screening and private practice optometrist examination

Of the 33 Caucasian children who undertook the HSE school screening, 3 children passed the screening and 30 children failed. Unaided vision or presenting vision as measured by the nurses was available for 15 children. The corresponding vision measurements from the nurses and optometrists were compared to see if there was absolute agreement between them (Intra Class Correlation). The results showed that there was no correlation between the measurements for presenting and unaided VA taken by both cadres as outlined in Table 7.3.3. The number of measurements in each of these categories is very
small. When all VA values from each cadre are considered (15 from each eye, 30 in total), the correlation is 0.42 which shows only a weak positive correlation between the two cadres.

Table 7.3.3: Comparison of mean visual acuity scores by nurses and optometrists

<table>
<thead>
<tr>
<th>Screeners Method</th>
<th>Visual Acuity (Mean &amp; SD)</th>
<th>Intra Class Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right Eyes</td>
<td>Left Eyes</td>
</tr>
<tr>
<td>Presenting visual acuity n = 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurses MAR</td>
<td>1.94 ± 0.91</td>
<td>1.64 ± 0.47</td>
</tr>
<tr>
<td>logMAR</td>
<td>0.29 ± -0.04</td>
<td>0.21 ± -0.33</td>
</tr>
<tr>
<td>Optometrists MAR</td>
<td>2.07 ± 1.03</td>
<td>1.60 ± 0.68</td>
</tr>
<tr>
<td>logMAR</td>
<td>0.32 ± 0.01</td>
<td>0.20 ± -0.17</td>
</tr>
<tr>
<td>Unaided visual acuity n = 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurses MAR</td>
<td>2.92 ± 3.20</td>
<td>2.94 ± 2.50</td>
</tr>
<tr>
<td>logMAR</td>
<td>0.47 ± 0.51</td>
<td>0.47 ± 0.4</td>
</tr>
<tr>
<td>Optometrists MAR</td>
<td>1.90 ± 1.06</td>
<td>2.38 ± 1.05</td>
</tr>
<tr>
<td>logMAR</td>
<td>0.28 ± 0.03</td>
<td>0.38 ± 0.02</td>
</tr>
</tbody>
</table>

*based on 8 measurements (4 right eye & 4 left eye) ^based on 22 measurements (11 right eye & 11 left eye) MAR 1.6 = logMAR 0.2 (6/9), MAR 1 = logMAR 0 (6/6). LogMAR values are the MAR mean and SD converted to logMAR.

The breakdown of the RE according to CAR category 1 (myopia, SE ≤ -0.50D; hyperopia, SE ≥ +2.00D) for the 30 children who failed the nurses screening is shown in
Table 7.3.4. Although this is a targeted cohort of children who failed the HSE school screening, Table 7.3.4 shows that approximately one third of fails were emmetropic. However it also shows that approximately two thirds of the children who failed and presented to the optometrist were in need of spectacle correction. Two children who failed the HSE school screening had esotropia; the length of their wait for a HSE eye examination was not recorded.

Table 7.3.4: Distribution of refractive error in participants who had previous assessment with the HSE community ophthalmic scheme

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Myopia number (%</th>
<th>Emmetropia number (%)</th>
<th>Hyperopia number (%)</th>
<th>Astigmatism number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presenting complaint: Fail Vision Screening</td>
<td>30/109</td>
<td>7 (23%)</td>
<td>12 (40%)</td>
<td>11 (37%)</td>
<td>15 (50%)</td>
</tr>
<tr>
<td>Presenting complaint: Waiting too long for HSE eye examination</td>
<td>10/109</td>
<td>1 (10%)</td>
<td>1 (10%)</td>
<td>8 (80%)</td>
<td>4 (40%)</td>
</tr>
<tr>
<td>Previously attended a community ophthalmic physician</td>
<td>21/109</td>
<td>5 (24%)</td>
<td>4 (19%)</td>
<td>12 (57%)</td>
<td>10 (48%)</td>
</tr>
</tbody>
</table>

The cycloplegic autorefraction outcome as defined by category 1 (Myopia \(\leq -0.50\)D and Hyperopia \(\geq +2.00\)D in either or both eyes and Astigmatism \(\leq -0.75\)D in the right eye).

Table 7.3.4 also shows the RE for the children whose presenting complaint was “overdue recall appointment to attend the community ophthalmic physician”. Among this cohort
there were 8 hyperopes, most of whom had spectacles and 3 of whom also underwent occlusion therapy. Two children with a strabismus (1 alternating esotropia and 1 esotropia) were examined by the community ophthalmic physician over a year ago. One attended the optometrist because the spectacles were damaged and the wait would be too long. One attended for a routine check-up with no symptoms.

All children were asked if they previously attended a community ophthalmic physician, regardless of whether or not their presenting complaint was related to HSE screening outcome. HSE screening is not the only entry to community ophthalmology e.g. parents can self-refer; siblings of children in the HSE system may be invited for an eye examination). Of the 109 total children, 21 children previously attended a community ophthalmic physician, 5 were myopic and 12 were hyperopic. Table 7.3.4 demonstrates the RE of this cohort. More than half this group were hyperopic, their treatment with the HSE included spectacles (4), spectacles and occlusion therapy (6) and in 2 cases no spectacles. Of the 5 myopes, 3 were prescribed spectacles, 1 was told there was no need for spectacles and the outcome of 1 myope was not known. Presenting spectacle prescriptions were available for 12 of the children with a fail on the HSE or who were waiting over a year for an eye exam. Each of these children required an updated (more myopic or hyperopic) prescription according to the CAR results.

3 children passed the HSE school screening. One child was emmetropic with slight astigmatism (-0.75D), the second child was anisometropic with more hyperopia in the LE (RE: +1.75D, LE: +3.63D). The third child who had previously attended a community
ophthalmologist, did not receive spectacles and who presented with reduced distance vision was significantly hyperopic in both eyes (RE: +4.25D, LE: +4.63D).
109 children were tested in this study which was the first to examine refractive data from the children attending private practice optometrists for eye examinations in the Republic of Ireland. The distribution of children according to gender was majority female (54%). The age distribution peaked at age 5 with the majority of children aged 5 - 12 years. This age distribution is due to the emphasis on primary school children for this study, because HSE screening takes place in primary school.

The main outcome of this study was that RE, according to category 1 (myopia, SE ≤ -0.50D; hyperopia, ≥ +2.00D) was present among 61% of the children examined by optometrists. The CAR results detected a large amount of myopia (23%), hyperopia (38%) and astigmatism (31%). The mean RE was hyperopic with a large standard deviation because of the wide range of RE in the small sample due to some of the children being very hyperopic and some being very myopic.

This was a targeted cohort of children who were highly likely to have RE so this study does not attempt to estimate prevalence. The recent epidemiological study conducted in Northern Ireland by O’ Donoghue et al. (2010) estimated myopia prevalence in 6 - 7 and 12 - 13 year old Caucasian children respectively as 2.8%, 95% CI [1.3% - 4.3%] and 17.7%, 95% CI [13.2% - 22.2%]. This is lower than the rate of 23% estimated among the targeted cohort in the current study. O’ Donoghue et al. (2010) estimated hyperopia prevalence in 6 - 7 and 12 - 13 year old Caucasian children respectively as 26%, 95% CI
[20% - 33%] and 14.7%, 95% CI [9.9% - 19.4%]. The current study was mainly conducted on a younger cohort and shows that more than half of the children with RE were hyperopic. The prevalence rates from Northern Ireland indicate that myopia becomes more prevalent in the older cohort of children. As outlined in the introduction (Section 7.1), the last HSE eye examination is offered at 12 years of age. Older children are not entitled to free HSE eye examinations unless they are medical cardholders or have an eye disease.

25.7% (n = 28) of the total cohort had presenting VA with spectacles measured, of these 3 had VI of worse than 0.3 logMAR in the better seeing eye. 20.2% of the children (n = 22) had unaided VA of worse than 0.3 logMAR in the better eye. Of these 50 children with VI only 8% (n = 4) still had VA worse than 0.3 logMAR in the better eye after refraction. Therefore most of the children attending the optometrist achieved better vision with a pair of spectacles.

With 8 cases of strabismus among this targeted cohort it is clear that children with binocular vision anomalies are attending Irish optometrists for refraction and management of the condition where appropriate. Esotropia was the main type of strabismus found in this targeted cohort. Two types of esotropia are refractive (which can be fully corrected with spectacles) and partially accommodative esotropia (which may be corrected with spectacles) (Evans 2007). Irish optometrists have the required competency and are well placed to carry out the regular cycloplegic refraction recommended for strabismus in particular esotropia (Mathur 2010).
The Irish Medical Organisation (2012) issued a strategic document stating that the community ophthalmic physician was the only HSE specialist and diagnostic community based eye service. It also stated that waiting lists of up to 4 years existed and pointed to a high number of false positive referrals from nurses, optometrists and general practitioners as the reason for the delayed care. The number of optometrists, ophthalmologists and orthoptists in Ireland is discussed in Section 4.4.

Interestingly more than 80% of children presented for an eye examination with symptoms or concerns. Approximately one third of children in this targeted cohort sought an eye examination due to a fail on the HSE school vision screening (27%) or were waiting too long for a HSE recall (9%). The second most common complaint was reduced distance vision (15%). If the HSE school vision screening had been effective, then ideally all children with reports of VI should be detected in the school vision screening and seen by the community ophthalmic physician. Since the school vision screening is only conducted at primary school entrance and exit, a child who develops myopia, for example, may go undetected for a number of years. The HSE provides free eye care for children who are referred from school screening or who have a referral from a medical practitioner (Government of Ireland 1970). All other children in primary schools have very restricted access to free eye care and may have to pay for a general practitioner appointment or an eye examination before they are referred to the HSE community ophthalmic physician.
The categories used to classify RE and the choice of refraction technique influence the number of cases of RE detected in a cohort. In study 1 category 2 was used with NCR in an attempt to detect more hyperopes to allow for the under estimation of hyperopia with NCR. From study 3 it is clear that using category 2 with NCR still underestimated the number of hyperopes. However since cycloplegic refraction data was gathered in this study, it was possible to devise equations to predict the CAR and CR values from the NCR values. This study confirms that NCR values are almost half as hyperopic as the CAR values for an individual. RESC studies advocate for CAR and CR as the best methods for detecting URE (Negrel et al. 2000). In circumstances where only NCR is possible these values can be converted to CAR estimates using the proposed equation “CAR = 0.57 + 1.08 * NCR”. Chan & Edwards (1994), Hong Kong, also devised a formula to estimate CRet from NCR results: CRet = 0.39 + 1.45 * NCR. Using the example of a NCR result of +1.50D the formula devised by the current study estimates a CAR result of +2.19D which is less hyperopic than the Chan & Edwards (1994) formula estimate of +2.57D for the same CRet result. Both formulae indicate that CRet underestimates hyperopia.

As discussed in Section 5.4.1 NCR was the only feasible method of objective refraction in Mozambique. A review of the literature investigating the accuracy of NCR at predicting the RE determined by cycloplegic methods was conducted. There may be a knowledge gap in this area. Bujara et al. (1980) analysed the NCR and CRet results of three ophthalmologists for 100 children. Bujara et al. (1980) determined that there was less variation in the cycloplegic results and recommended CRet for RE measurement.
Funarunart et al. (2009) stated that NCR and NCSR were clinically accurate when compared with cycloplegic refraction (n = 120) on a study involving children aged 6 – 13 years in Thailand. The Thai study recommended that these non cycloplegic techniques be incorporated into school screening for RE. In the current study NCR performed by experienced optometrists in a test room setting with appropriate lighting, target and working distance, corresponded well to all cycloplegic tests. From the recommendations from Funarunart et al. (2009) and the current study it may be worthwhile to trial the addition of NCR by optometrists to the Irish school screening protocol.

The least reliable non cycloplegic predictor of cycloplegic results in the current study was the NCAR. Several studies confirmed that NCAR was a poor predictor of the cycloplegic refraction and tended to over minus the actual RE (Rao et al. 2015, Funarunart et al. 2009, Fotouhi et al. 2012, Choong et al. 2006, Zhao et al 2004, Williams et al. 2008). Fotouhi et al. (2012) reported that differences between the NCAR and CAR results depended on the age of the subjects and cycloplegic refraction category. This may indicate that the use of non cycloplegic auto refraction by untrained personnel in a primary school screening is not ideal. Rao et al. (2015) compared NCAR and CAR to CRet measurements on children (n = 200) age 8 – 15 years. Rao et al. proposed that where there is limited skilled eye care professionals CAR ought to be conducted by less skilled personnel as there was a good agreement between CAR and CRet results among this cohort. However Rao et al. did not state who performed the measurements in this study and did not assess the accuracy of NCR compared with CRet. Williams et al. (2008) conclude that non cycloplegic data may contribute to vision science with the
caveat that they under estimate the prevalence of hyperopia. In Ireland there is strict governance over who may administer medication (cycloplegic drops). Optometrists are permitted to administer eye drops for diagnostic purposes.

As expected there was very little difference in detection rates between each method of refraction for the number of cases of astigmatism. There was a strong positive correlation between NCR, CAR and CR. This means that NCR gives a reliable estimate of the cases of astigmatism in a cohort. Similarly Kothari and Hussein (2015) found that there was very little difference in the mean astigmatism between non cycloplegic and cycloplegic autorefraction (0.3 ± 1.1 95% CI, [0.1 – 0.8]).

Among the pilot cohort of 33 children (30/33 failed the screening); nurses identified 7 cases of myopia and 11 cases of hyperopia. In one case the nurse passed a hyperopic child but referred the child to an optometrist due to the child expressing asthenopic symptoms. Of the 33 children screened by the nurses, 13 were hyperopes. HSE school screening is based on the level of VA. In studies 1 and 2, VA did not prove to be a good detector of hyperopia. Therefore there may potentially be many undetected hyperopic children in schools. Although this is a targeted cohort it was previously established that VA is not a good screener for RE therefore the nurse screening may be a conservative representation of the number of hyperopes in the primary school population. In addition 12 (40%) children who reported a fail on the vision screening were emmetropic. This indicates that the nurse screenings are causing false positives to be referred into an
already strained system. It is most likely that false positives on vision screening would be
detected with NCR or CRet during optometrist led eye health screening.

As there were few results (n = 15) for the ophthalmic nurses and corresponding
optometrists VI results it was not possible to draw conclusions from their intra class
 correlation figures. Interestingly ophthalmic nurses recorded a worse unaided VA
compared to the optometrist VA values. The researcher is unsure about the conditions
and chart used by the nurses to conduct their VA measurements. There are several
practical issues that may influence the VA results, these include: giving limited time for
letter resolution; recording the whole line when only part of it was viewed; poor lighting
conditions in the examination room. More research ought to be carried out to determine
the accuracy, sensitivity and specificity of HSE screening.

It is clear that some children in this cohort who were examined by the HSE nurse or
community ophthalmic physician previously were in need of a new eye examination. The
strain on the HSE system discussed in the introduction means that children are not getting
prompt eye care where there is a clinical need. This study only investigated the cases
where parents could afford to pay for private eye care. Another issue is that parents may
not be aware that they can bring their children to the optometrist for an eye examination.
There may be many more children not receiving eye care in a timely manner, who are
visually impaired and may be at an increased risk of developing amblyopia. The United
Kingdom Association of Optometrists, (2001) advocated for optometrists and orthoptists
to be involved in the primary care of children, referring to the community ophthalmic
physician after 3 months if there is no improvement in VA in amblyopia or refractive strabismus. This study also advocates this approach.

7.4.1 Limitations of the study

A blurring lens was used in study 3 for NCR whereas it was not used in study 1. This may have caused the NCR in study 3 to more strongly correlate with the CRet results. In addition the testing in the Irish study took place in a quiet eye examination room with controlled lighting and equipment familiar to the optometrist. This implies that the retinoscopy results may have been more accurate in study 3 compared with study 1. A further study ought to compare retinoscopy results without using a burring lens for NCR and comparing it with CAR results.

As with study 1 this was a study on a targeted cohort so no prevalence estimates should be inferred from this data. No demographic data was gathered from the nurses who screened vision. It would be interesting to assess if there is a relationship between the nurses training levels and their vision screening outcomes.

The HSE (2006) also lists the types of visual acuity charts which should be used (see Section 4.4). No information was gathered on the type of chart the nurse used to screen. It was beyond the scope of this study to examine the method of visual acuity measurement employed by nurses or the environment in which they conduct the measurements (e.g. ambient lighting condition; accuracy of test distance). In many cases in study 3 the
optometrist reported verbatim that there was a fail on the HSE school screening. Parents either lost or forgot their screening results form. It was not possible in the timeframe of this study to verify each reported fail. An audit of the nurse screening was conducted in Northern Ireland (Donnelly et al. 2006). The audit found the service to be of a high quality. Perhaps a similar audit ought to be conducted in the Republic of Ireland.
7.5 Conclusion

This study was the first to examine RE, as determined by CAR, in school children in Ireland. There were 25 (22.9%, 95% CI [0.15% – 0.31%]) cases of myopia and 41 (37.62%, 95% CI [0.29% – 0.47%]) cases of hyperopia among this targeted cohort. The percentage of uncorrected, presenting (with previous spectacles), and best-corrected VA of 0.32 logMAR or worse in the better eye, expressed as a percentage of the total cohort, was 20.2%, 2.8%, and 3.7%, respectively. Strabismus, mainly esotropia, was present in 7.3% of the total cohort. Only 17% of children presenting for an eye examination had no symptoms.

Category 2 for NCR was found to underestimate the amount of hyperopic cases (n = 6) in the cohort so an equation was proposed to estimate the CAR value. Category 2 overestimated the number of myopic cases (n = 2). In this targeted cohort the NCR results predicted the CAR results using the proposed equation. Based on these studies, category 2 is a good predictor of significant RE with NCR. Where NCR is the preferred method of screening e.g. in Mozambique where there are limited resources, using category 2 will identify significant hyperopia and myopia. Otherwise where cycloplegic examination methods are used to detect RE, category 1 should be applied to the results. Where NCR is the only method available to estimate RE then the proposed equation (for CAR) can be used to minimise error due to active accommodation. CAR astigmatism correlated well with NCR astigmatism, the difference between the means -0.07 ± 0.35, is minor. When compared to the NCR, the CAR detected slightly more astigmatism (Wilcoxon Signed Ranks Test, z = -2.05, p = 0.04).
The Irish government has legislated to provide free ophthalmic care to primary school children. However children with VI, RE and in some cases strabismus presented to Irish optometry practices for private eye examinations between March and July 2015. Over one third had previously been assessed by a public health ophthalmic nurse or community ophthalmic physician and these children were in need of an eye examination. Although this was a targeted cohort of children it is clear that not enough ophthalmic care is provided by the state.

In addition, of the 30 children with a fail on the HSE screening, 12 were found to be emmetropic on assessment by an optometrist. The level of VA measured by nurses was lower than that measured by optometrists. Further research ought to be conducted to review the HSE paediatric community ophthalmic care scheme to identify ways to provide more prompt, efficient eye care for children. A situational analysis ought to be conducted to recommend staffing, training and equipment requirements. This review ought to include a study to monitor and evaluate the HSE school screening outcomes. One potential improvement to the current screening would be the inclusion of NCR by nurses or optometrists on all HSE fails and a random sample of the passes. This could be conducted on the same day as the nurse’s visit to the school.

Chapter eight will summarise the conclusions and recommendations derived from the 3 studies. The results found in this thesis will be compared with the relevant published literature.
8 CHAPTER EIGHT: CONCLUSION AND FUTURE STUDIES

8.1 Conclusions

Different CEH interventions in Mozambique and Ireland were explored in this thesis. The challenges to CEH in Nampula and Ireland are diverse. Both countries, although vastly disparate in terms of culture, economy and society are in need of comprehensive programmes to combat inadequate CEH. Mozambique, with limited resources, has very little primary eye care. Ireland, a relatively rich country has public primary eye care, but there are some deficits in its well established system which are outlined in this thesis.

The task of detecting and treating URE and VI in both countries provided an informative contrast. Ireland has a more developed health system as well as a large private sector of optometry practices to combat the problem whereas Mozambique as a developing nation is only at the beginning of a journey Ireland began many decades ago.

In Mozambique no child presenting with URE or VI was wearing spectacles. Therefore children are being denied their human right to ophthalmic medical treatment as outlined in Section 1.1. Low spectacle coverage among children is a problem in many countries including South Africa (Naidoo et al. 2003) where only 12 children out of 63 with significant RE were wearing spectacles in the RESC. Adults in Mozambique are also living with URE as shown by the 0% spectacle coverage rate in the RARE (Loughman et al. 2014).
Study 1 detected a low amount of myopia, hyperopia and astigmatism in the targeted cohort examined. In Mozambique even a small prevalence of URE means that a large number of children (approximately 92,000 in Nampula, 585,000 in Mozambique) are engaging in education with URE. This study highlighted the need for a prevalence study to be carried out in Mozambique to determine the estimated number of children requiring spectacles. There was also a low rate of URE prevalence 2.6%, 95% CI [2.1% - 3.2%] found by the RARE study in Mozambique (Loughman et al. 2014).

In study 2, teachers were proven to be effective vision screeners for myopia using the 0.3 logMAR screening chart, as found in two previous studies which were carried out in China (Sharma et al. 2008) and in Tanzania (Wedner et al. 2000). In both studies the children examined were older and myopia was highly prevalent. Bai et al. (2014) stated that the amount of spectacle wearing children in schools where vision screenings had occurred was not significantly higher than in schools where no screening was conducted. Bai et al. (2014) concluded this from a questionnaire filled out by the principal, it is not clear who performed these screenings. Limburg et al. (1999) reported a poor result from teacher vision screening in India. In study 2 neither teachers nor optometry students were effective at screening for hyperopia which was the most prevalent URE among the children examined in Nampula. Ruiz – Alcocer et al. (2011) estimated the prevalence of myopia to be 13% in young adults. Perhaps self vision screening and referral would be useful in Mozambican universities.
In study 3 Irish nurses failed 12 (37% of total screened) emmetropic children during the school vision screening. A high level of false positive referrals from nurses, General Practitioners and optometrists was one of the reasons cited by the Irish Medical Organisation (2012) for the long waiting lists to see a community ophthalmic physician. Donnelly et al. (2006) stated that nurse school screening in Northern Ireland, which was audited prior to study 3, was found to be of high quality. No further information was given how the quality of the screening was assessed. Nurses in Canada (negative predictive value 98%), United Kingdom (sensitivity 77%), and Oman (sensitivity 68%), were found to be accurate screeners for both reduced VA and URE (de Becker et al. 1992, Jewell et al. 1994, Khandekar et al. 2004). Kvarnstrom et al. (2001) stated that the accuracy of the nurses at screening for various ocular conditions improved with increasing age of the child. With a sensitivity of 30% reported for children aged 3 years and 70% for children aged 10 years.

O’ Donoghue et al. (2012) stated that vision screening had limited capacity to detect hyperopia and astigmatism. Powell et al. (2004) questioned the efficacy of vision screening in high income countries like the United Kingdom. Powell et al. (2004) stated that children in the United Kingdom are likely to be receiving treatment by the time school screening was conducted. In addition, there was not enough evidence to show effectiveness and the positive impact of screening on children’s lives. O’ Donoghue et al. (2012) suggested that more work ought to be carried out to evaluate if vision screening in conjunction with other refractive tests is more effective at detecting URE among 4 – 5 year olds. As vision screening alone cannot be relied upon for URE detection (O’
Donoghue et al. 2012), spending extra money on crowded logMAR acuity charts and time refining a VA measurement during school eye health screening may be a waste of resources. The present study advocates the use of the one line crowded logMAR 0.2 Illiterate E screening chart as a vision screening tool to detect children with VI, alongside objective refraction in both countries. It is a quick, easy to reproduce, easy to use chart purely for screening.

This thesis recommends that CAR be conducted by optometrists for the detection of RE in prevalence studies internationally. Using CAR will allow comparison with most international studies as it is the most commonly used method to determine URE (Maul et al. 2000; Negrel et al. 2000; Pokharel et al. 2000; Zhao et al. 2000; Dandona et al. 2002; Murthy et al. 2002; Naidoo et al. 2003; He et al. 2004; Goh et al. 2005, Mohamed et al. 2014, Fotouhi et al. 2007). Both CRet and CAR were conducted in the RESC studies and were proven to be highly reproducible (Maul et al. 2000; Pokharel et al. 2000; Zhao et al. 2000; Dandona et al. 2002; Murthy et al. 2002; Naidoo et al. 2003; He et al. 2004; Goh et al. 2005).

Rao et al. (2015) recommended that further studies ought to be conducted to examine the exact correction factor for non cycloplegic findings. CRet was considered by Rao et al. (2015) to be the gold standard, because up until the recently there was no accurate alternative. The results from CRet certainly compared well to the CAR (Spearman’s rho $r_s = 0.91$) results in study 3. Where cycloplegia is not possible, NCR is recommended.
with the caveat that it will underestimate the number of hyperopes in the study population. Consideration must then be given to how URE is categorised.

There are a number of categories in use to determine URE. The recommendation from study 3 is that category 1 is used in conjunction with CAR to classify URE. To date no study has been carried out to determine which category would be the best to use where only NCR results are available. Study 3 compared the NCR results for the most commonly used category 1 with the adapted category 2. It used the CAR SE results as the gold standard. The recommendation from study 3 is that for NCR results category 2, which has a lower cut off value for hyperopia and a higher cut off value for myopia, ought to be employed. Although the analysis of the NCR results using category 2 compared with the CAR results underestimated the amount of hyperopic cases (n = 6) in the cohort. The majority of children examined were mild hyperopes (mean = +2.33D). The NCR astigmatism result is a good predictor of astigmatism since it correlated well to the CAR astigmatism (Spearman’s rho \( r_s = 0.66 \), 95% CI [0.52 - 0.77]).

In summary, in Ireland the recommendation from study 3 is that CAR ought to be conducted by optometrists or skilled eye care professionals on all children in school eye health screening. CAR in school screening is not feasible in Mozambique currently and may prove not to be feasible in Ireland either. Therefore this thesis recommends that in Mozambique NCR and vision screening (0.2 logMAR) should be conducted by optometrists (in addition to cover test and ophthalmoscopy) in primary schools. Category
2 and the equation “CAR = 0.57 + 1.077 * NCR” ought to be used as a guide to decide which children should undergo CRet.

Strabismus was prevalent in the Northern Irish study by Donnelly et al. (2006) and the South African RESC study (Naidoo et al. 2003). Strabismus was detected in both the Mozambican (0.7%, 95% CI [0.1% - 1.2%]) and Irish (6.8%, 95% CI [2.2% - 11.4%]) children. Both groups were targeted cohorts so prevalence estimates cannot be inferred from these rates. The number of cases detected in Mozambique was a low estimate as cover test was performed on less than half of the children. The presence of strabismus in both cohorts suggests a school eye health screening protocol should include the cover test to detect strabismus.

Ophthalmoscopy carried out by skilled eye care professionals ought to be included in school eye health screening in both countries. The amount of ocular abnormality present in the targeted cohort in Mozambique was high. Loughman et al. (2013) trialled computer based glaucoma screening test on adults in the community in Nampula. The percentage of field defects detected was not included in the published data. Consideration ought to be given to rolling out post graduate glaucoma training for the optometrists in Mozambique. This test was found to be suitable for use in the community with repeatable results. Bourne et al. (2012) stated that optometrists with specialised knowledge in glaucoma detection, treatment and management helped to reduce the rate of false positive glaucoma referrals into hospitals in the United Kingdom. As discussed in Section 6.3.4 a trachoma initiative aimed to reduce the prevalence of trachoma by 2019 is underway.
The mixed methods approach adopted in study 2 was an ideal way to consider issues around CEH and potential teacher vision screening in Nampula. It explained that vulnerable children are usually outside the education system and often most in need of eye care. Study 2 highlighted several barriers to CEH among all children in Nampula. Expanding on the quantitative outcomes from the teacher vision screening, study 2 highlighted numerous systemic and socioeconomic barriers to teacher vision screening. Mindful of the limited resources available to the Mozambican government, study 2 highlighted the potential for collaboration among existing community initiatives for primary child eye care activities.

Study 3 showed that children in Ireland in the care of the public system are attending private practice optometrists for eye examinations and updated spectacles due to the lengthy delay in follow up public appointments. This indicated that not enough timely ophthalmic care is being provided by the Irish HSE. Study 3 highlighted that optometrists are performing private eye examinations on children in Ireland. To date optometrists skills have not being utilised for publically funded community based paediatric eyecare. Indeed the school health guidance document (HSE 2006) did not mention optometrists in the section on school vision screening. It recommended that orthoptists conduct the vision screening. The findings of this study suggest that optometrists are ideally placed in the community to deliver paediatric eyecare and have the skill set to carry out more comprehensive eye health screening than is currently provided by the public paediatric eye care system in Ireland.
This study highlights the need for an enhanced CEH intervention in Ireland which ought to use the facilities of the public health system in conjunction with the expertise of optometrists. As is evident in this thesis optometrists have the necessary expertise and are already examining children who fail the HSE vision screening. With the introduction of new legislation around the scope of optometry practice as discussed in Section 4.4, optometrists are ready to play a more central role in HSE primary eyecare.

Optometrists have the potential to play a more central role on the community ophthalmic team through direct employment. HSE optometrist’s responsibilities ought to include conducting school eye health screening and performing full eye examinations in public health centres. If direct employment of optometrists is not feasible perhaps children’s eye examinations ought to be included on the existing ophthalmic contract between the HSE and private practice optometrists.

8.2 Future studies

8.2.1 Future studies in Mozambique

Based on the findings of this thesis a prevalence study of RE, URE, VI and ocular abnormalities in children, similar to the RESC (Naidoo et al. 2003), is required in Mozambique. A prevalence study would inform planning for any CEH intervention.
There are now 29 employed optometrists with more graduating yearly. They increase the capacity of the Ministry of Health to provide primary eye care. The promotion of eye care services ought to be carried out by the Ministry of Health. In Nampula, as a result of the ocular abnormalities detected in this study, it is recommended that children, teachers, parents and community leaders are educated on prevention, detection and treatment of eye disease and infection.

In Nampula further work ought to include a feasibility study which looks at the cost and potential economic and health benefits of a CEH initiative. As there may be many children with poor eye health outside the education system planning for a CEH initiative in Nampula ought to include engagement with local communities and families. In addition, this engagement ought to include influential community members (chiefs and traditional healers) and a broad spectrum of NGDO and government stakeholders including those involved in water, sanitation and hygiene.

Abnormal ocular conditions were prevalent in the Mozambican children. Although Perera et al. (2015) suggest the Snellen vision screening smartphone apps are not reliable when compared with Snellen wall charts; the smartphone can make eye health screening more efficient (Chakrabarti et al. 2012). Relaying fundus imaging back to an ophthalmologist either in real time or by uploading to a network on return from the field may assist in the prioritising and fast referral of children with abnormal ocular conditions. The feasibility of including this imaging technology in community eye health screening ought to be explored.
8.2.2 Future Studies in Ireland

In Ireland further research ought to be conducted to review the HSE paediatric community ophthalmic care scheme to identify ways to provide more prompt, efficient care for children and training and equipment requirements. This review ought to include a study to monitor and evaluate the HSE school screening outcomes. This review may include an evaluation of the sensitivity and specificity of nurse vision screening. This may consist of optometrists conducting CAR, ophthalmoscopy and the cover test on all vision fails and a random sample of the passes. This ought to be conducted on the same day as the nurse’s visit to the school.
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National Treatment Purchase Fund (2015). *Out-patient waiting list – ophthalmology*


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Appendix 3.1

List of members of the Mozambique Eye care Coalition

Organisation

Ministry of Health
Ulls do Mundo
Light for the World
Sight Savers International
International Trachoma Initiative
Help Age
Norwegian Association of the Blind and Partially Sighted
Brian Holden Vision Institute
Helen Keller International
Dublin Institute of Technology
Appendix 5.1

Study 1 data collection for school eye health screening

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<td></td>
<td></td>
</tr>
</tbody>
</table>

KEY: Or: Orade M/F: Masculino/Feminino Vision/Viso 0: Pass 1: Fail (<4 letters seen) Ret: 0: ret performed no sign URE 1: ret performed sig URE 3: not performed
Refl/Referal 0: Direto 1: Indireto
Int/Internal/Interno 0: Healthy 1: Cataract 2: Glaucoma 3: Other please name

Source: Brien Holden Vision Institute (2009)
Appendix 5.2

Table A5.2.1 Statistical analysis from the logistic regression, part 1

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>.348</td>
<td></td>
<td></td>
<td>2</td>
<td>.840</td>
<td></td>
</tr>
<tr>
<td>School(1)</td>
<td>.288</td>
<td>.513</td>
<td>.315</td>
<td>1</td>
<td>.575</td>
<td>1.333</td>
</tr>
<tr>
<td>School(2)</td>
<td>.061</td>
<td>.500</td>
<td>.015</td>
<td>1</td>
<td>.903</td>
<td>1.063</td>
</tr>
<tr>
<td>Sex(1)</td>
<td>-.589</td>
<td>.426</td>
<td>1.915</td>
<td>1</td>
<td>.166</td>
<td>.555</td>
</tr>
<tr>
<td>age3cat</td>
<td>.393</td>
<td></td>
<td></td>
<td>2</td>
<td>.822</td>
<td></td>
</tr>
<tr>
<td>age3cat(1)</td>
<td>.336</td>
<td>.538</td>
<td>.390</td>
<td>1</td>
<td>.533</td>
<td>1.399</td>
</tr>
<tr>
<td>age3cat(2)</td>
<td>.148</td>
<td>.503</td>
<td>.087</td>
<td>1</td>
<td>.769</td>
<td>1.160</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.374</td>
<td>.509</td>
<td>44.018</td>
<td>1</td>
<td>.000</td>
<td>.034</td>
</tr>
</tbody>
</table>

a. Variable(s) entered on step 1: School, Sex, age3cat.

Table A5.2.2 Statistical analysis from the logistic regression, part 2

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>2.364</td>
<td></td>
<td></td>
<td>2</td>
<td>.307</td>
<td></td>
</tr>
<tr>
<td>School(1)</td>
<td>-1.072</td>
<td>.802</td>
<td>1.787</td>
<td>1</td>
<td>.181</td>
<td>.342</td>
</tr>
<tr>
<td>School(2)</td>
<td>-.642</td>
<td>.587</td>
<td>1.194</td>
<td>1</td>
<td>.274</td>
<td>.526</td>
</tr>
<tr>
<td>Sex(1)</td>
<td>-1.016</td>
<td>.593</td>
<td>2.932</td>
<td>1</td>
<td>.087</td>
<td>.362</td>
</tr>
<tr>
<td>age3cat</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>.312</td>
<td></td>
</tr>
<tr>
<td>age3cat(1)</td>
<td>.745</td>
<td>.648</td>
<td>1.323</td>
<td>1</td>
<td>.250</td>
<td>2.107</td>
</tr>
<tr>
<td>age3cat(2)</td>
<td>-.140</td>
<td>.717</td>
<td>.038</td>
<td>1</td>
<td>.845</td>
<td>.869</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.281</td>
<td>.581</td>
<td>31.844</td>
<td>1</td>
<td>.000</td>
<td>.038</td>
</tr>
</tbody>
</table>

a. Variable(s) entered on step 1: School, Sex, age3cat.
Appendix 5.2

Table A 5.2.3: Statistical analysis from the logistic regression, part 3

Parameter Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>t</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Intercept</td>
<td>.790</td>
<td>.081</td>
<td>9.697</td>
<td>.000</td>
<td>.630</td>
</tr>
<tr>
<td>[Sex=0]</td>
<td>-.060</td>
<td>.068</td>
<td>-.881</td>
<td>.378</td>
<td>-.193</td>
</tr>
<tr>
<td>[Sex=1]</td>
<td>0^a</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>[age3cat=.00]</td>
<td>.037</td>
<td>.090</td>
<td>.410</td>
<td>.682</td>
<td>-.139</td>
</tr>
<tr>
<td>[age3cat=1.00]</td>
<td>-.031</td>
<td>.079</td>
<td>-.396</td>
<td>.692</td>
<td>-.187</td>
</tr>
<tr>
<td>[age3cat=2.00]</td>
<td>0^a</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>[School=1]</td>
<td>-.108</td>
<td>.086</td>
<td>-.1257</td>
<td>.209</td>
<td>-.276</td>
</tr>
<tr>
<td>[School=2]</td>
<td>.108</td>
<td>.080</td>
<td>1.341</td>
<td>.180</td>
<td>-.050</td>
</tr>
<tr>
<td>[School=3]</td>
<td>0^a</td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

a. This parameter is set to zero because it is redundant.

Table A 5.2.4: Breakdown of uncorrected refractive error according to locality

<table>
<thead>
<tr>
<th>Locality</th>
<th>Students Screened (% of total)</th>
<th>Emmetropia (% of total)</th>
<th>Myopia (% of total)</th>
<th>Hyperopia (% of total)</th>
<th>Pearson Chi Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>205 (27.4)</td>
<td>185 (24.7)</td>
<td>6 (0.8)</td>
<td>14 (1.9)</td>
<td>(\chi^2 = 0.91)</td>
</tr>
<tr>
<td>Semi-urban</td>
<td>274 (36.6)</td>
<td>248 (33.1)</td>
<td>7 (0.9)</td>
<td>19 (2.5)</td>
<td>p = 0.92</td>
</tr>
<tr>
<td>Rural</td>
<td>270 (36.0)</td>
<td>249 (33.2)</td>
<td>5 (0.7)</td>
<td>16 (2.1)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>749 (100)</td>
<td>682 (91.1)</td>
<td>18 (2.4)</td>
<td>49 (6.5)</td>
<td></td>
</tr>
</tbody>
</table>

Rural children were the least myopic. There is no significant association between location and URE category 2.
Appendix 6.1

Teacher screening record card

<table>
<thead>
<tr>
<th>No</th>
<th>Name of Student</th>
<th>Data</th>
<th>Age</th>
<th>Right Eye</th>
<th>Left Eye</th>
<th>Refer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: International Agency for the Prevention of Blindness (2009)
Appendix 6.1

Example of request for permission letter – translation of letter to Provincial Director for Education (Page 1)

Exma Senhora

Director Provincial da Saúde,

Dr*. [Redacted]

Subject: Request for a meeting and permission for training activities for the Universidade Lúrio optometry programme.

The Eye Care Project (Eyecare Project), and the optometry program at the University Lúrio, I would like to ask the permission of Your Excellency to develop eye exams for children in schools locations in Nampula on 15, 16 and 17 September. Five Optometrists Ireland and Northern Ireland (UK) will visit schools, accompanied by University Lúrio optometry students.

If permission is granted to visit schools, all children in each school will be examined, using simple tests that have no effect on the child. Details are presented in Appendix 1.

We would like to request the Your Excellency an opportunity to present a research project future that includes the development of a regional strategy for examination observation care eyes needed to Nampula, which may involve the training of teachers or workers medical care in order to perform the examination of eyes to discover ocular abnormalities as a cause of visual impairment or blindness in a school environment, where vision is so critical in child’s learning and development. We are currently in the process of asking for approval ethics for this project, but would like to discuss this with the Your Excellency, according to your availability.

We would like to meet with Your Excellency between 15-17 September, possibly during dinner, or at Your Excellency’s office, according to your availability to discuss the proposed strategy on children eye care, the first of its kind in Mozambique.

Best wishes, Sincerely,

Dra. Aoife Phelan  aoife.phealan@dft.ie 0035314024904
Optometrista
Dr. Jose Pons
Director da Faculdade de Ciências de Saúde
Appendix 6.1

Example of request for permission letter – translation of letter to Provincial Director for Education (Page 2)

Appendix 1

The Eye Care Project (Eyecare Project) University of Mozambique involves partners University Lúrio, Nampula, and the International Centre for Eye Care Education (ICEE), in collaboration with the Dublin Institute of Technology and University of Ulster in a program funded by Irish Aid, which aims to support the Mozambican government in eliminating avoidable blindness Mozambique. This program facilitates the recruitment and training of optometrists in an Optometry program currently underway in University Lúrio in Nampula.

These students will be trained as optometrists to (1) determine the need for glasses to correct refractive error, (2) to make the glasses necessary by cutting and fitting the correct lenses and (3) find out other causes of blindness and vision problems that require referral to an ophthalmologist at the hospital.

As V. Excia knows, good vision is extremely important for learning and education, and for the lives of children. Young people’s sight can be significantly improved by the provision of appropriate glasses, or referral for medical treatment where necessary. The ability to perform an eye exam on a child is very different the examination in an adult. Our students therefore require specialist training in art observation (or examination) young child. Students entering the second year of their training are currently receiving instruction in the basic techniques of examination of an eye.

The Eye Care Project and the optometry program at the University Lúrio would like to ask the permission of V. Excia to develop eye exams for children in local schools in Nampula on 15, 16 and 17 September. Five Optometrists of Ireland and of Ireland North (UK) will visit schools, accompanied by Optometry students at the University Lúrio. If permission is granted to visit schools, children in each school will be examined, using simple tests that have no effect on the child, including: 1) Overview of measurement - the child will read a letter board, numbers or figures according to the case for check whether the level of vision is normal. 2) Measurement of refractive error - a light (retinoscope) and a number of lenses are used to determine the power of glasses necessary where a child has reduced vision, 3) Ocular Health Check - a light (ophthalmoscope) will be used to observe the child's eyes to determine the presence of any other eye abnormalities affecting the child. Any child who requires glasses will have a free pair of glasses provided by the Lúrio University clinic, which will be opened in the coming months. Any child who is found to have an eye health problem will be forwarded to Dr. [Redacted] in Nampula Central Hospital. We would also ask for the opportunity to speak with students, teachers, and school directors about the importance of vision in school work, and the detection of vision problems affect children in the classroom. It is important to note that all tests will be administered and will be supervised by optometrists qualified of Ireland and Northern Ireland. Students will be present to help, assist optometrists at work, help with translation and practice certain exams. This is an important component of clinical training of Lúrio University optometry students. The activity will benefit optometry training substantially, but above all, will significantly benefit the children who participate in schools and teachers working there.
Appendix 6.2

Example of Interview Aims and Questions

Representatives of small Portuguese NGDO, March 2012
(conducted through English)

Aim:
To gather information on the type of work a small charity involved in schools in Nampula does,
To identify the challenges for the NGO, children, Ministry of Education.
To get a better idea of a day in the life of a typical child in Nampula.
To learn more about how the education system works

Questions:
What aspects of health if any are included in the primary school curriculum?
What do you know about the school health programme?
What NGOs in Nampula work in school health?
What NGOs nationally work in school health?
Are there school health learning materials?
How are teachers trained in school health?
Could eye health be introduced into in service and training for teachers?
Could you tell me more about the regional and local education structure?
What is teacher turnover like?
What school health projects exist in nampula and who is involved?
Identification of the key stakeholders in education and health in Nampula?
What activities do you know of to support school health? Why?
Who are the activities reported to?
How would eye health guidelines help community activists and geracao biz?
Appendix 6.2

Electronic Questionnaire

March 2013 Electronic Questionnaire for Child Eye Health Study in Nampula

Hi, I am Dra Aoife Phelan, a research optometrist with Dublin Institute of Technology, working with University of Lurio. I am currently conducting a study investigating visual impairment among children in Nampula. This questionnaire is designed to give information on the everyday challenges to children attending school in Nampula. Your response will be anonymous and make an important contribution to my study. Thank you for taking the time to complete this questionnaire.

1. From your own contact with neighbours and friends what are all the factors that affect the cost of education for a local family?

2. From your own experience living in Nampula, do you have suggestions as to why children are not in school?

3. From your experience is it common for children to take care of blind/sick relatives instead of attending school?

4. If yes why?

5. Any example of initiatives that work with people with disabilities in Nampula / Mozambique?

6. From living in Nampula can you comment on the challenges which you have observed around water sanitation and hygiene of a school aged child?

7. Can you comment on the care or education of orphaned children (street kids) or disabled children?

8. Are there other groups of children who may not be going to school?

9. From your experience of living in Nampula did you observe or experience any barriers to children obtaining an education?

10. Can you comment as to whether or not there is social stigma in Nampula around spectacle wear?

Is wearing spectacles perceived positively or negatively by people in Nampula in your experience?

12. How many School sessions are there each day?

13. Any further comments?
## Appendix 6.3

### Table A 6.3: Themes and Subthemes with supporting quotes

<table>
<thead>
<tr>
<th>Theme</th>
<th>Subtheme</th>
<th>Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Education</strong></td>
<td>Quantity (Schools)</td>
<td>&quot;...with the distances of the school and students do walk, and principally of the poor teaching quality, that leads to demotivation and abandonment, i.e., classrooms with more than 100 students, sometimes reaching 150, without tables and chairs, no walls and many times the teachers are missing&quot;  &quot;A teacher in secondary school could have 125 students in class, by the time all names are called the 45 minute session would be over&quot;.</td>
</tr>
<tr>
<td></td>
<td>Quality (Teachers and Principals)</td>
<td>&quot;And of course the concentration is minimal and even good teachers, do not engage the students and this is the most important step for the student to have basic schooling!&quot;</td>
</tr>
<tr>
<td></td>
<td>Access (Cost of Education to the family)</td>
<td>&quot;Sending children to work eg clothes washing, if children are not at work they are not earning a wage&quot;  &quot;Uniforms cost $1-5 which is a large amount to families who have much less to spend, it’s not a priority and they wear out.&quot;  &quot;Poor children do not attend school for lack of funds. Without the material children are not allowed into the class.&quot;</td>
</tr>
<tr>
<td><strong>Community</strong></td>
<td>Other Vulnerable Groups</td>
<td>&quot;... children take care of their younger siblings, or any other relative who is ill. An ill or blind person cannot do anything for themselves, so there is need of another person, in most cases a child, to help them to beg money in the street.&quot;  &quot;The state or welfare system is too weak to care for disabled relatives so it falls to the relatives of the individual. The elderly are well respected in the community and their care is seen as a duty and not a chore. It is cheaper for children to mind relatives than adults as their earning potential is less.&quot; (NGDO)  &quot;.....Also being illiterate, they did not understand the bureaucratic process involved with arranging a birth certificate.&quot; (NGDO)</td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td>Under Resourced Public Service</td>
<td>&quot;...there is a lot of corruption by teachers and they are always asking for daily contributions, which become impossible for many families, which often leads to dropout or failure of the student if he does not pay the teacher.&quot;</td>
</tr>
<tr>
<td></td>
<td>Perception of Spectacle Wearers</td>
<td>&quot;There is no stigma. Actually it is the opposite, glasses is another way of adornment, means beauty for children, youth and older people. But I never saw a child with spectacles.&quot;</td>
</tr>
<tr>
<td></td>
<td>Children with mental or physical disabilities, deformities</td>
<td>&quot;The care and education or with this type of child is very low or almost nil, it doesn’t exist, they are left to their fate and without attention at all.&quot;</td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td>Education and Health Ministry Links</td>
<td>&quot;There is no paediatric focussed officer working in the Provincial Directorate for Health. If a health programme arises eg health weeks, nutrition or oral health a supervising officer will be appointed.&quot;</td>
</tr>
<tr>
<td></td>
<td>(Eye) Health services for Children</td>
<td>&quot;...the ophthalmology service of the central hospital does not give a positive response, cases that I have followed are always without success!&quot;</td>
</tr>
<tr>
<td></td>
<td>Water and Sanitation and Hygiene</td>
<td>&quot;The conditions are not the best and most of the families live in slums, surrounding by garbage and without running water or toilets. That water is not potable, so it is not suitable for drinking, however, they use it for everything and keep it in their houses accumulating lots of germs and bacteria.&quot;</td>
</tr>
</tbody>
</table>

**Source:** Questionnaires and Semi structured Interviews
Appendix 7.1

Information pack and study protocol

DIT Eye Study Protocol

Booking Appointment:
Inform parent of the following:
1. The child will undergo a normal sight test.
2. Request that the parent bring the HSE letter informing of result of school screening (if applicable).
3. The practice is participating in a DIT child eye study. Before the eye exam the parent will be given information on the study and asked to consent to the anonymised exam findings being used in a national study.
4. Drops will be inserted into the child’s eyes, with their assent, to get an accurate prescription.

Before the test:
Give the parent the information sheet and the consent form to sign. If the child is 10 years old or older give them the ‘child information sheet’ to read. Children over 10 years should sign the consent form in the space provided, in addition to the parent’s signature. Verbal assent should then be obtained from children before putting in the drops.
If consent or assent is not obtained please fill in a brief summary of the reasons on the Non-Participating Child List.

Eye Exam:
Optometrist checks that the consent sheet has been signed by the parent and child (if 10yrs or over).
Optometrist writes the child’s study code on the test sheet, conducts a normal eye exam, filling in the findings on the study test sheet. See below for detailed explanation of eye exam protocol.

After the Eye Exam:
Optometrist gives the child a certificate of participation.
Optometrist scans the test sheet, auto refractor printouts and signed consent form, email to the researcher (a clear photo taken with a phone may suffice). Post the original sheet and form to Aoife Phelan.
Appendix 7.1

Information pack and study protocol

Case History
It is an important aspect of the study to record the results of the HSE school screening outcome where the child presents to the practice having undergone school screening. Please ask the parent if the child recently had a vision screening in school. The reason for attending private practice should also be noted. Where no letter is available from the school screening take note of the result of screening (pass/fail) on test sheet.

Visual Acuity
See the protocol diagram attached.

Binocular vision tests
The study investigates amblyopic risk factors present in primary school children. Assessment of heterophoria/tropia at distance (at least 3.5 m, using the smallest letter on the logMAR chart that could be seen clearly with each eye) and near (33 cm, using an appropriately sized fixation target on the Budgie Stick) using the cover/uncover test both unaided and with spectacles if worn. Please quantify any phoria or tropia found using the prism bar.

If it is not possible to assess the binocularity with the cover test, where possible, the Hirschberg test should be performed. A corneal reflex within the pupillary margin, approximately 1mm from the pupillary centre will be noted as 19 Dioptres. The Krimsky method will be used to align the corneal reflex. As this is a study by optometrists it would be most useful and methodologically sound to use the Cover Test and Hirshberg as a backup.

Stereopsis, Ophtalmoscopy, Slit Lamp examination of the anterior segment, Near point of convergence (NPC) and Accommodative amplitude should be performed on each child.
Appendix 7.1

Information pack and study protocol

**Non cycloplegic refraction:**
Non cycloplegic autorefractron, retinoscopy and subjective refraction are to be performed first. Near visual acuity and amplitude of accommodation tests should be performed.

All children taking part in the study must undergo a cycloplegic refraction. For the purpose of this study even children who are apparently emmetropic should have a cycloplegic refraction.

**Insertion of Drops:**
Verbally inform the child and parent of the purpose and potential side effects of the two drugs to be used. Ask for verbal assent from the child for the drops to be inserted. Tick box on test sheet. Show the parent the expiry date and name written on the package. Insert 1 drop of 0.5% proxymetacaine hydrochloride into each conjunctival sac, followed by 1 drop of 1% cyclopentolate hydrochloride. Ask the child if they feel well. Observe the child for a few minutes, watch for any side effects of the drops. After 30 minutes check that pupils are not reacting to light and pupil diameter has increased to 6mm or more. For dark irides dilate with 2 drops of 1% cyclopentolate eye drops, administered 2 times 5 minutes apart. After 45 minutes evaluate light reflex and pupil dilation.

**Cycloplegic Refraction:**
Cycloplegic autorefractron, retinoscopy and subjective refraction are to be performed.

**Please Note:**
Primary school children who present to the practice but do not take part in the study should have minimal data entered on the non-participating children code sheet, along with the reason.
Appendix 7.1

Information pack and study protocol

LogMAR Protocol Wall Chart

<table>
<thead>
<tr>
<th>Monocular distance visual acuities (unaided and presenting) must be measured at a distance of at least 3 meters, using the LogMAR chart.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE first, then LE, each time occluding the fellow eye. Observe to prevent squinting</td>
</tr>
<tr>
<td>Begin - at least 3.5 meters (check chart type) with the top line (1.0 or 6/6).</td>
</tr>
<tr>
<td>If at least 4 out of 5 optotypes are correct go to line 4 (0.7 or 6/30).</td>
</tr>
<tr>
<td>If one or less optotypes are missed, resume at line 7 (0.4 or 6/15), continue to line 10 (0.1 or 6/7.5) and finally line 11 (0.0 or 6/6) or as far as possible.</td>
</tr>
<tr>
<td>If at any level the child fails to recognize 4 out of 5 optotypes, the line immediately above the failed line is tested, until successful.</td>
</tr>
<tr>
<td>If the top line is missed, the child is advanced to 1 (or 2 check chart type) meter with progression down the chart as described above.</td>
</tr>
<tr>
<td>The lowest line read successfully is assigned as the visual acuity for the eye undergoing testing.</td>
</tr>
<tr>
<td>If the child is noncompliant with the distance logMAR chart, it is recommended that the Sonsken test chart be used.</td>
</tr>
</tbody>
</table>

Monocular and binocular near LogMAR acuities should be measured at 25cm using the Bailey Lovie Near Charts provided.
Appendix 7.1

Information pack and study protocol

**Child Code Sheet**
Optometrist No ______ Practice No_____(Keep safe, post to researcher at the end of study)

<table>
<thead>
<tr>
<th>Initials</th>
<th>DOB dd/mm/yy</th>
<th>Phone</th>
<th>Parent Email</th>
<th>Study No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

**Non Participation Child Code Sheet**
Optometrist No______ Practice No.(Keep safe, post to researcher at the end of study)

<table>
<thead>
<tr>
<th>Assign No</th>
<th>Age (not DOB)</th>
<th>Reason for non-participation: eg no consent or assent</th>
<th>Study No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**School Code Sheet**
Optometrist No______ Practice No(Keep safe, post to researcher at the end of study)

<table>
<thead>
<tr>
<th>School Name</th>
<th>Study No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DIT Eye Study Test Sheet (please do not enter child’s name on sheet)

<table>
<thead>
<tr>
<th>Optom No</th>
<th>Practice no</th>
<th>Child No</th>
<th>School No</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Main presenting symptom</td>
<td></td>
</tr>
<tr>
<td>Ethnic Group:</td>
<td>Irish (tick for yes)</td>
<td>other:</td>
<td>Reason for attending</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex:</td>
<td></td>
<td>Male=1 Female = 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results stated on the HSE screening letter (if available, affix copy)

<table>
<thead>
<tr>
<th>Distance Vision</th>
<th>Right</th>
<th>Left</th>
<th>Binoc</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>with present glasses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unaided</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Information:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Has child attended the HSE community ophthalmologist (tick for yes) | |
Outcome of ophthalm. visit:

Previous eye surgery
Right | Left |

Visual Assessment monocular then binocular

<table>
<thead>
<tr>
<th>LogMAR Distance Vision</th>
<th>Right</th>
<th>Left</th>
<th>Binoc</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>with present glasses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unaided</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LogMAR Near Acuity

<table>
<thead>
<tr>
<th>with present glasses</th>
<th>Right</th>
<th>Left</th>
<th>Binoc</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>unaided</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ocular Alignment (Method: Cover Test=C Hirschberg =H)

<table>
<thead>
<tr>
<th>D Result:</th>
<th>final rx</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D Result:</td>
<td>final rx</td>
<td></td>
</tr>
<tr>
<td>N Result:</td>
<td>unaid</td>
<td></td>
</tr>
<tr>
<td>N Result:</td>
<td>final rx</td>
<td></td>
</tr>
</tbody>
</table>

Stereopsis Meth. | |
Stereoaucity | |
Tick if performed, (please perform)
Ophthalmoscopy | Slit Lamp | Motility | |
Pupils | NPC | Amp Accommod |

Non Cycloplegic Refraction

Focimetry of Current Spectacle (If applicable affix printout, label “FOC” or enter below)

| Right | | | | |
| Left | | | | |

Non Cycloplegic Auto Refractor Results (enter result in brackets <> staple results print out to sheet. Label “NCAR”)

| Right | | | | |
| Left | | | | |

Non Cycloplegic Retinoscopy (1st check LE for with movement; fog sufficiently. Use +1.50DS @67cm insert result – 1.50 WD lens)

| Right | | | | |
| Left | | | | |

Non Cycloplegic Subjective Refraction

| Right | | | | LogMAR VA |
| Left | | | | |

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Appendix 7.2

Eye Examination form Page 2

**DIT Eye Study Test Sheet** (please do not enter child’s name on sheet)

<table>
<thead>
<tr>
<th>Cycloplegic Refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child verbal assent given</td>
</tr>
<tr>
<td>Cycloplegic Auto Refractor Results</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cycloplegic Retinoscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cycloplegic Subjective Refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
</tbody>
</table>

**Action needed (circle as appropriate)**

<table>
<thead>
<tr>
<th>Optical</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
</tr>
<tr>
<td>Spectacles</td>
</tr>
<tr>
<td>Return for repeat refraction</td>
</tr>
<tr>
<td>Refer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vision Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthoptic exercises</td>
</tr>
<tr>
<td>Patch under care of optometrist</td>
</tr>
<tr>
<td>Patch recommended refer to orthoptist/other please specify</td>
</tr>
<tr>
<td>Strabismus refer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medical</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
</tr>
<tr>
<td>Medication</td>
</tr>
<tr>
<td>Surgery</td>
</tr>
<tr>
<td>Specify</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Full Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Eye</td>
</tr>
<tr>
<td>Left Eye</td>
</tr>
</tbody>
</table>
Appendix 7.3

Parent Pack - Consent Form

TAKING PART IN THE Dublin Institute of Technology Eye Study

Please discuss the study with your child, TICK THE APPROPRIATE BOX AND SIGN BELOW.

☐ Yes, I give permission for my son / daughter to take part in the Dublin Institute of Technology Eye Study, including having the measurements outlined.

☐ No, I do not wish my son / daughter to take part in the Dublin Institute of Technology Eye Study

Name of Child: ____________________________ Child’s Class: ____________________________

Child’s Date of Birth: ____________________________ Child’s School: ____________________________

Signature of Parent or Legal Guardian ____________________________ Date __________

Name of Parent or Legal Guardian (please print) ____________________________

Signature of Child (if 10 yrs or over) ____________________________

Name of Child (please print) ____________________________

YOUR CHILD’S HEALTH If your child has any specific health problem which you think might be important please give details here. If your child suffers from an allergy to eye drops they should not take part in the study. If you have any doubts or queries we will be happy to talk these over with you.

ADDRESS Please write your email address here, so that we can keep in touch with you about the results of the study.

If you are not sure about any part of this consent form or wish to discuss it with us, please telephone (0863843051) or email us at aoife.phelan@dit.ie Please put ‘Eye Study’ in the subject heading of the e-mail.

Please return this form to the optometrist. Thank you for your help

Source: O’Donoghue (2008)
Appendix 7.3

Parent Pack - Child Information Sheet

Child Information Sheet

We would like to ask you and other children visiting the practice to help us with an important study, looking at the health of children’s eyes. We hope that the study will help us to find out more about the eyes of children and to understand why some people do not see clearly.

What will the study involve?
We would like to use the information from your eye exam today. He or she will measure:-

🔍 How well you can see- by reading some letters on a chart (or by recognising some shapes), and whether you might need glasses to help you see better.
🔍 The glasses prescription that suits you best - to do this we will need to use a special machine and we will need to put special drops in your eyes. The drops can irritate a little bit when they are first put into your eyes, but this only lasts for a few seconds. The drops will make your vision blurry, and your pupils (the black part in the middle of the eye) larger for several hours. You may have difficulty reading and you will not be able to play sports today. You may also find lights are brighter than usual. These effects do not last long and your eyes will soon be back to normal.
🔍 We will also take a photograph of the back of each eye and you will be able to see what it looks like.

What happens when I have finished the tests?
🔍 Certificate- To show that you have played an important part in this research, we will give you a special certificate to say 'thank you'.

Thank you for reading this letter. We hope you will be able to take part in this study. Please fill in the reply form with your parent or carer. If you have any questions, you can contact us by telephone, email or by writing to us at the address below.

Aoife Phelan
Dublin Institute of Technology, National Optometry Centre, 19A Kevin Street, Dublin 8.
P: 0863843051 E: aoife.phelan@dit.ie

Source: O'Donoghue (2008)
Appendix 7.3

Parent Pack - Drug Information Sheet

Drug Information Sheet

You had two different types of eyedrops instilled into your eyes today. The name of the first eye drop we used is

PROXYMETACAIN HYDROCHLORIDE 0.5%.

This drop is a mild local anaesthetic, used to numb the surface of your eye, which will enhance absorption and facilitate instillation of the drops that reduce the focusing power of the eye. The drops take about 60 seconds to work and around 25 minutes to wear off. You should avoid situations where you might get dust or grit into your eye as you will not be able to feel any discomfort straight away. It is very unlikely, but should you experience any unusual symptoms such as pain, soreness or blurred vision during this period please contact your optometrist or GP as you may be experiencing an adverse reaction to the drops.

The name of the second eye drop that we instilled is

CYCLOPENTOLATE HYDROCHLORIDE 1.0%.

This drop is used to allow an accurate reading of your eyes’ prescription by suspending its focusing system. The drops take about 30 to 45 minutes to work and around 12 hours to wear off (in some cases up to 24 hours). The large pupils will make you more sensitive to light and distant and near objects may appear slightly blurred. The optometrist will have recommended therefore that you shouldn’t perform any physical activities such as cycling for at least 12 hours after the drops have been instilled. On a bright day, sunglasses may be advisable also. It is very unlikely, but should you experience any unusual symptoms such as severe pain and/or a blood shot eye and cloudy vision during this period please contact your optometrist or GP as you may be experiencing an adverse reaction to the drops.

Source: O’Donoghue (2008)
Appendix 7.3

Parent Pack - Parent Information Sheet page 1

Dear Parent / Guardian,

We would like to invite your child (and other children visiting the practice) to take part in an important study examining the health of children’s eyes. Research suggests that seeing well in childhood can have important effects on the ability to learn and vision in later life. We are very keen to include your child in this study, whether they use glasses or not, to ensure that this study provides a true picture of eye health in today’s children.

What would taking part in the study involve?

For your child: Your child will have their eyes examined with the optometrist today. The optometrist will perform a normal eye exam. To measure the need for glasses accurately we will need to put some drops into each eye which will make the pupils larger (the black part in the middle of the eye). The drops can irritate a little for a few seconds when they are first put into the eyes. Your child may find lights brighter than usual during this time. Vision may be blurred slightly for up to 12 hours after we put the drops in, hence your child may find school work a little blurred, and we advise that your child does not take part in physical activities or sports during this time. The drops can cause a reaction but this is very rare (less than 1 in 10,000 people). When it occurs a rash appears on the face and the child feels hot and light-headed. These reactions go away naturally the same day without treatment. The eye examination itself will take half an hour or so, after which they will be given a special certificate to thank them for participating in the study. The optometrist will explain the tests to your child and to answer questions.

For you: We would like you to consent for the details from your child’s routine eye examination, carried out in the optometry practice, to be anonymized and used as part of a study on children who present to optometry practices for an eye exam.

Source: O’Donoghue (2008)
Appendix 7.3

Parent Pack - Parent Information Sheet page 2

What will happen after the study?
We will look at the results from children’s eye exams all over Ireland.

We hope very much that your child will be able to take part in the survey — many other children have now taken part and have found it both enjoyable and interesting. All information from the study will be treated in complete confidence. Please discuss the study with your child (details of the tests are shown on the information sheet for children that accompanies this letter) and fill in the consent form enclosed to say whether or not your child will take part. The form should be signed by a parent or legal guardian. Please give the consent form to the optometrist. If you would like any further information please telephone us on 0863543051 or email aoife.phealan@dit.ie.

Thank you very much for your help.

Ms Aoife Phealan FAOI Dr Veronica O Dwyer FAOI
Study Leader Study Director

Source: O’Donoghue (2008)
Appendix 7.4.

Intra class correlation test results

*Table A 7.4.1: Intra Class Correlation test results for each optometrist versus the researcher*

<table>
<thead>
<tr>
<th>ID</th>
<th>Ret p1</th>
<th>VA p1</th>
<th>AR p1</th>
<th>SR p1</th>
<th>Ret p2</th>
<th>VA p2</th>
<th>AR p2</th>
<th>SR p2</th>
<th>Ret p3</th>
<th>VA p3</th>
<th>AR p3</th>
<th>SR p3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.974</td>
<td>0.993</td>
<td>1</td>
<td>0.934</td>
<td>0.968</td>
<td>0.95</td>
<td>0.925</td>
<td>1</td>
<td>0.923</td>
<td>0.997</td>
<td>0.896</td>
<td>0.963</td>
</tr>
<tr>
<td>2</td>
<td>0.999</td>
<td>0.984</td>
<td>0.999</td>
<td>0.992</td>
<td>0.99</td>
<td>n/a</td>
<td>0.993</td>
<td>0.999</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<td>0.994</td>
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<tr>
<td>3</td>
<td>0.774</td>
<td>0.963</td>
<td>0.999</td>
<td>0.789</td>
<td>0.999</td>
<td>0.939</td>
<td>1</td>
<td>0.999</td>
<td>0.88</td>
<td>0.964</td>
<td>0.999</td>
<td>0.999</td>
<td>0.942</td>
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<td>4</td>
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<td>0.708</td>
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<td>1</td>
<td>0.946</td>
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<td>0.996</td>
<td>0.959</td>
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<td>5</td>
<td>0.999</td>
<td>0.832</td>
<td>0.977</td>
<td>0.998</td>
<td>1</td>
<td>0.989</td>
<td>0.998</td>
<td>1</td>
<td>1</td>
<td>0.829</td>
<td>0.986</td>
<td>0.997</td>
<td>0.967</td>
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<tr>
<td>6</td>
<td>0.999</td>
<td>0.944</td>
<td>0.769</td>
<td>0.552</td>
<td>0.833</td>
<td>0.899</td>
<td>0.967</td>
<td>0.999</td>
<td>0.977</td>
<td>0.94</td>
<td>0.866</td>
<td>0.992</td>
<td>0.895</td>
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<tr>
<td>7</td>
<td>0.24</td>
<td>0.964</td>
<td>0.792</td>
<td>0.774</td>
<td>0.982</td>
<td>0.913</td>
<td>0.968</td>
<td>0.978</td>
<td>0.748</td>
<td>0.982</td>
<td>-0.237</td>
<td>0.922</td>
<td>0.752</td>
</tr>
<tr>
<td>8</td>
<td>0.998</td>
<td>0.951</td>
<td>0.995</td>
<td>0.993</td>
<td>0.99</td>
<td>1</td>
<td>0.999</td>
<td>1</td>
<td>0.999</td>
<td>0.921</td>
<td>1</td>
<td>1</td>
<td>0.987</td>
</tr>
<tr>
<td>9</td>
<td>0.868</td>
<td>0.972</td>
<td>n/a</td>
<td>0.992</td>
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<td>0.998</td>
<td>0.905</td>
<td>1</td>
<td>1</td>
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<td>0.998</td>
<td>1</td>
<td>0.9716</td>
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<td>10</td>
<td>0.99</td>
<td>0.987</td>
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<td>1</td>
<td>0.901</td>
<td>0.827</td>
<td>1</td>
<td>1</td>
<td>0.999</td>
<td>0.991</td>
<td>0.993</td>
<td>1</td>
<td>0.9725</td>
</tr>
</tbody>
</table>

*ID – optometrist identification number; Ret – noncycloplegic and cycloplegic retinoscopy; p1 – patient 1; VA – presenting/unaided visual acuity; AR - noncycloplegic and cycloplegic autorefraction; SR - noncycloplegic and cycloplegic subjective refraction; p2 – patient 2; p3 – patient 3; n/a no values from a tester; * - no child available; Mean – mean of all the Intra Class Correlation measurements for each optometrist.*
Appendix 7.4.

Table A7.4.2: Spearman correlation for visual acuity measurements

<table>
<thead>
<tr>
<th></th>
<th>Spearman Correlation</th>
<th>[95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Right Eye</td>
</tr>
<tr>
<td>Unaided visual acuity</td>
<td>78</td>
<td>0.9</td>
</tr>
<tr>
<td>both eyes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presenting visual</td>
<td>25</td>
<td>0.81</td>
</tr>
<tr>
<td>acuity both eyes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected visual</td>
<td>105</td>
<td>n/a</td>
</tr>
<tr>
<td>acuity right eye</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n/a – correlation between right eye and left eye measured

Table A7.4.3: Wilcoxon Signed Rank test for each test performed

<table>
<thead>
<tr>
<th></th>
<th>NCAR</th>
<th>NCRet</th>
<th>NCSR</th>
<th>CAR</th>
<th>CRet</th>
<th>Cycloplegic subjective refraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAR</td>
<td>-</td>
<td>-6.423b</td>
<td>-4.695b</td>
<td>-8.651b</td>
<td>-7.894b</td>
<td>-8.135b</td>
</tr>
<tr>
<td>NCRet</td>
<td>-6.423b</td>
<td>-</td>
<td>-3.990c</td>
<td>-7.510b</td>
<td>-7.894c</td>
<td>-6.147c</td>
</tr>
<tr>
<td>NCSR</td>
<td>-4.695b</td>
<td>-3.990c</td>
<td>-</td>
<td>-8.171c</td>
<td>-8.100c</td>
<td>-7.779c</td>
</tr>
<tr>
<td>CAR</td>
<td>-8.651b</td>
<td>-7.510b</td>
<td>-8.171b</td>
<td>-</td>
<td>-.212b*</td>
<td>-4.756b</td>
</tr>
<tr>
<td>CRet</td>
<td>-7.894b</td>
<td>-7.894c</td>
<td>-8.100c</td>
<td>-0.212b*</td>
<td>-</td>
<td>-4.195b</td>
</tr>
<tr>
<td>Cycloplegic subjective refraction</td>
<td>-8.135b</td>
<td>-6.27</td>
<td>-7.779c</td>
<td>-4.472</td>
<td>-4.195b</td>
<td>-</td>
</tr>
</tbody>
</table>

p = 0.00 (2 tailed) for all values except for * p=0.832
b. Based on negative ranks.
c. Based on positive ranks.