INFLUENCE OF OUTDOOR AND NEAR WORK ACTIVITIES ON MYOPIA AMONGST SECONDARY SCHOOL STUDENTS IN LURAMBI SUB-COUNTY, KAKAMEGA, KENYA

Alfred Ragot

A Thesis Submitted to School of Public Health Biomedical Sciences and Technology in Partial Fulfilment of the Requirements for the Award of Degree of Master of Science in Optometry and Vision Science of Masinde Muliro University of Science and Technology

November, 2020

DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and it has not been presented elsewhere for a degree or any other award.

Alfred Ragot

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CERTIFICATION

The undersigned certify that they have perused and hereby recommend for acceptance of Masinde Muliro University of Science and Technology a thesis entitled **"Influence of Outdoor and Near Work Activities on Myopia amongst Secondary School Students in Lurambi Sub-County, Kakamega, Kenya."**

Signature  **Date:…….**

Prof. Peter Clarke-Farr, PHD

Department of Optometry

Cape Peninsula University of Technology

Signature: **Date:……..……**

Dr. Mustafa Baraza, PHD

Department of Medical Laboratory Sciences

Masinde Muliro University of Science and Technology

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DEDICATION

I dedicate this thesis to my family for their continuous support throughout the entire period.

ACKNOWLEDGEMENT

I take this opportunity to acknowledge God for giving me strength to complete this thesis. I would also like to appreciate Dr. Mustafa Baraza and Prof Peter Clarke-Farr, for the technical support in supervising this thesis. I acknowledge the contribution of other supervising lecturers for their tireless support and my colleagues for their continuous advice and guidance. My appreciation also goes to Masinde Muliro University of Science and Technology, particularly, the department of Optometry and Vision Science – I am grateful for the logistical support and opportunity given to me to undertake this academic endeavour.

ABSTRACT

The prevalence of myopia has disturbingly escalated globally with an estimation of up to 2.56 billion cases by the end of 2020. Almost half of the earth's inhabitants are estimated to be myopic by the year 2050, while a fifth of the world's population will have its attendant vision threatening conditions by then. In Kenya, the prevalence has risen from 6% to 15% in urban settings. Myopia is said to be the foremost cause of visual impairment in Kenya contributing to a total of about 59.5% of the visual impairment. Till date, consensus on the exact aetiology and risk factors for myopia is not clearly documented. However, increased near-related activities and little outdoor time have been increasingly associated with myopia, even though the indication is not entirely reliable. This study's aim was to evaluate the influence of near work and outdoor activities on myopia amongst randomly selected secondary school students from Lurambi sub-county of Kakamega County in Kenya. The specific objectives were to determine; the prevalence of myopia, sociodemographic distribution of myopia, level of outdoor and near work activities amongst myopic and non-myopic students as well as to establish the relationship between outdoor activities, near work activities and myopia. The study adopted an analytical cross-sectional study design. By the use of multi-stage sampling technique, through random selection from a population of 7,400 secondary school students in Lurambi Sub-County, 733 participants were selected and classified clinically as myopic and non-myopic. Those who met the study's inclusion criteria were taken through standard optometric vision protocol to determine individuals with myopia, while pre-tested near-tasks and outdoor-time questionnaires were administered to both the myopic and non-myopic. The prevalence of myopia was found to be 7.5% and males were more myopic than females. It was established that myopia was more prevalent in 16-year-olds and in the urban areas. 431(63.6%) and27(49.1%) of non-myopic and myopic students respectively reported to taking part in sporting and outdoor activities, while 222(32.7%) of non-myopic and 46(83.7%) of myopes reported to not spending plenty of time outdoors. 40(72.8%) of myopes reported to having extra revision classes often, out of which 30(54.5%) reported to having 6 classes. 38(69.1%) of myopes agreed that when reading they always held their books closer to their eyes with a proximity of 10 to 25cm. A logistic regression analysis showed that there was no significant influence of outdoor activities on having myopia, $\chi^2_{(8)} = 9.75$, p=0.059). While there was significant influence of near-work activities on having myopia ($\chi^2_{(14)} = 44.122$, p= 0.005, having extra/revision classes daily or during weekends increased the probability of having myopia OR, 3.983; 95% CI, [1.78-8.89]; p=0.001. To add on, having more hours for extra classes or revision increased probability of myopia OR, 2.017; 95% CI, [1.39-6.50]; p= 0.005. On the other hand, reducing the number of hours spent reading newspapers reduced probability of having myopia by 0.88. In conclusion, the study reported an association between near-related activities and having myopia. Near related activities are modifiable factors hence they can be modified in schools to control for the myopia development and progression. This, in essence, is a cost-effective interventional strategy to control myopia.

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LIST OF ACRONYMS AND ABBREVIATIONS

AVC	-	Academic Vision Centre
D	-	Dioptre (unit of lens power measurement)
IERC	-	Institutional Ethics Research Committee
KCSE	-	Kenya Certificate of Secondary Education
Log MAR	-	Logarithm of the Minimum Angle of Resolution
MMUST	-	Masinde Muliro University of Science and Technology
SEH	-	Sabatia Eye Hospital
SPSS	-	Statistical Package for Social Sciences
URE	-	Uncorrected Refractive Error
VA	-	Visual Acuity
VI	-	Visual Impairment
WHO	-	World Health Organization

OPERATIONALIZATION OF TERMS

Cycloplegic: Drug which dilates the pupil and temporarily paralyses the ciliary body.

Myopia: Refractive error, also known as "near-sightedness", where visual acuity is good at near and poor at distance.

Near work activities: Some of the activities with short working distance (what is always referred to as 75 cm or less) (Li *et al.*, 2015).

Outdoor activities: Some of the activities that are done outside a building in the sun (Rose *et al.,* 2008).

Refraction: Determining the refractive error of the eye.

Rural schools: Schools found outside Kakamega municipality.

Urban schools: Schools found inside Kakamega municipality.

Visual acuity: Degree of sharpness of central (macular) vision.

Visual Impairment: Visual acuity <6/18 but equal to or better than 3/60 in the better eye with best possible correction. Category 1 (Visual impairment) is visual acuity less than 6/18 to 6/60. Category 2 (severe visual impairment) is visual acuity less than 6/60 to 3/60 (Gordon *et al.,* 2003).

CHAPTER ONE

INTRODUCTION

1.1 Background Information of the Study

Myopia, also known as short-sightedness, is a condition that occurs when a far object's view is formed before the eye's retina. This is most often due to more grounded refractive power of the eye in comparison with the axial length of the eyeballs (Vera-Diaz, 2010). An epidemiological research study depicted myopia as a refractive error equal or greater than -0.50 dioptres (Ds) (Morgan *et al.,* 2018).

Myopia is the leading cause of distance uncorrected refractive error (URE) and cantered on the present estimation and demographic tendencies, there's a plausibility of it being the key cause of visual impairment (VI) in the event that it's left unattended (Morgan, *et al.,* 2012). Myopia is the foremost common eye condition around the world and its predominance is essentially escalating. It is alleged to be a public health issue internationally (Holden *et al.,* 2016) and 1 out of 5 ocular issues that have been pinpointed by World Health Organization as prompt need for a worldwide intervention on preventing vision impaired (VI) (Holden *et al.,* 2014). This is due to the fact that it escalates the possibility of other blinding disorders like cataract, choroidal degeneration, retinal conditions and glaucoma even with the optical correction (Saw *et al.,* 2005).

It is projected that myopia affected 1.893 billion of the global population in 2010. It has been established that East Asia contributes the most in terms of prevalence, with about more than half of its populace set to contract irreversible VI due to myopia (Belete *et al.,* 2016). Prevalence of myopia is predicted to be more than 50% of the whole populace in Singapore, Japan, China and the Republic of Korea. The

anticipation is that by year 2050, myopia will influence 52% of the global population (Holden *et al.,* 2016).

The predominance of myopia is estimated to be 1.7% in Africa (Paediatric Eye Disease Study Group, 2010). Various studies carried out in Kenya postulates the scarcity of the predominance of myopia and its risk factors. Hyperopia has been the most common refractive error (Muma *et al.,* 2009), however , there has been a shift since myopia is now considered the most widespread refractive error (Nyamai *et al.,* 2016). Myopia is said to be the main cause of visual impairment in Kenya and it contributes to 59.5% of the refractive errors (Baraza *et al.,* 2013). In spite of this, prevalence of myopia in Kakamega county and by extension Lurambi sub-county is unknown.

Njeru *et al.,* (2013) determined the prevalence of myopia to be 6.7% in Kenya. This is believed to further upsurge due to the intensive near work that is ascribed to the surge in educational demand and reduced outdoor activities, mostly in schools that are integrating advanced learning in their academic system (Pan *et al.,* 2012). Nevertheless, controversies exist among studies on the influence of outdoor activities and near work activities in the development of myopia.

There has been a connection of myopia to ethnicity and genetics, with little interrelation to environmental factors (Goldschmidt & Jacobsen, 2014). However, this has been recently changing since the development and increment in prevalence have been sudden that the change cannot be connected to the alterations in the myopia gene pool (Huang *et al.,* 2018). It has also been established that ethnic differences do not explain the increase in prevalence and its variation in different countries. This is because significant differences in prevalence has been recorded

for children with the same ethnic background living in different locations or countries (French *et al.,* 2013; Ip *et al.,* 2008). This explains why myopia is considered more environmentally associated than genetically correlated.

The two major environmental factors which have been associated with myopia are restricted outdoor activities and intensive near work (Williams *et al.,* 2015), despite the conflicting literature on the exact influence they have on myopia. Outdoor and near work activities are modifiable environmental factors as opposed to the other risk factors of myopia (Hsu *et al.,* 2016), making them ideal for studies. Inconsistency in literature on the exact influence of outdoor activities and near work activities on myopia (Li *et al.,* 2015; Sherwin *et al.,* 2012; Tideman *et al.,* 2019; Wu *et al.,* 2015; You *et al.,* 2016) informed this study.

1.2 Problem Statement of the Study

Approximately, over half of the globe's population will be myopic by 2050 should nothing be done, with as much as 10% expected to have vision threatening conditions as a result (Bourne *et al.,* 2017). In spite of this disturbing escalation of predominance of myopia and high myopia worldwide with other parts experiencing as high as 90% predominance, the studies on its aetiology and its dangers has not been properly recorded.

Myopia and high myopia can lead to additional vision endangering conditions like retinal detachment, choroid degeneration, macular degeneration and cataract conditions (Ramamurthy,*et al.,* 2015; Chua, *et al.,,* 2005). The threat is comparable to the dangers of smoking to cardiovascular disorders (Morgan *et al.,* 2018a). To add on, myopia has been linked to the substandard quality of living (Wong *et al.,* 2009).

Myopia has been established to be the leading source of visual impairment in Kenya especially among adolescents (Baraza *et al.,* 2013b). Despite Lurambi sub-county being one of the sub counties in Kenya with the highest number of adolescents (KNBS, 2019), prevalence and risk factors of myopia are still unknown.

The main risk elements associated with myopia are limited open-air activities and greater near work (Huang *et al.,* 2018), although some studies have dismissed the relationship between myopia and near work plus outdoor activities. This demonstrates that there is no link between near work activities and myopia. Also, participating in outdoor activities may be clinically significant but not statistically significant in the onset and development of myopia (Wu,*et al.,*2015;Myrowitz *et al.*,2012; Duan *et al.,* 2015).

This study was informed by the disagreement of literature on the influence of out-of-doors activities and near work activities on myopia and the fact that most of the studies done are on Caucasians. Hence this research study was carried out to establish the possible influence of outdoors and near work activities on the myopia amongst secondary school students in Lurambi Sub-County.

1.3 Objective of the Study

1.3.1 Broad objective

Determining the influence of outdoor activities and near-related activities on myopia amongst secondary school students in Lurambi Sub-County was the broad objective of this study.

1.3.2 Specific objectives

To attain the broad objective of this research study, such specific objectives were developed as listed below:

i. To determine the predominance of myopia among secondary school students in Lurambi Sub-County.
ii. To determine the socio-demographic distribution of myopia among secondary school students in Lurambi Sub-County.
iii. To determine the level of outdoor activities among myopic and non-myopic secondary school students in Lurambi Sub-County.
iv. To determine the level of near related activities among myopic and non-myopic secondary school students in Lurambi Sub-County.
v. To determine the relationship between outdoor activities, near-related activities and myopia among secondary school students in Lurambi Sub-County.

1.4 Research Questions

i. What is the prevalence of myopia among secondary school students in Lurambi Sub County?
ii. What is the socio-demographic distribution of myopia in secondary school students in Lurambi Sub County?
iii. What is the level of outdoor activities among myopic and non-myopic secondary school students in Lurambi Sub County?
iv. What is the level of near related activities amongst myopic and non-myopic secondary school students in Lurambi Sub-County?

v. What is the relationship between outdoor activities, near-related activities and myopia amongst secondary school students in Lurambi Sub-County?

1.5 Hypothesis

The following hypothesis was tested:

Hypothesis 1:

$H_{o:}$ There is no significant relationship between out-of-doors activities, near work activities and myopia.

$H_{a:}$ There is a significant relationship between outdoor activities, near work activities and myopia.

1.6 Justification of the Study

Recently, prevalence of myopia has been rapidly increasing , mostly in the adolescents and is setting off to be a pandemic (Goldschmidt & Jacobsen, 2014). Lurambi sub-county is believed to be one of the sub counties in Kenya that has the highest number of adolescents (KNBS, 2019), yet there is no evidence of any study on prevalence and risk factors of myopia. The scarce studies that have been conducted on myopia in Kenya, has established it to be the most predominant refractive error contributing 59.2% of the entire refractive errors (Bastawrous *et al.,* 2013). The reason for the rise in predominance is not clearly established, considering the correlation between increment of prevalence and environmental variables, especially outdoors and near work activities (Lyhne *et al.*,2001). However, this was conducted on a Caucasian population and may not be translated to Kenya due to differences in race, environment, lifestyle, and cultural practices. Thus, this demonstrates the need for this study. Also, the study was set to ascertain the pervasiveness, social demographic distribution and level of outdoor and

near work activities of myopic and non-myopic secondary school students in Lurambi Sub-County.

1.7 Significance of the Study

The findings of this thesis were anticipated to provide an empirical basis for policy organizing and activism on the alteration of environmental aspects such as outdoor activities and the quantity of near work activities in schools in order to control myopia. The findings were further expected to form the basis for policy formulation regarding the Kenyan national big agenda of universal health care with reference to eye health.

Also, the findings of the study were expected to contribute towards awareness of the role of environmental factors, specifically open-air exercises and near work, as chance variables for myopia development. The thesis adds up to the pool of information on the environmental variables such as open-air exercises and near work, and how they add to myopia predominance disposition in various population groups.

1.8 Scope of the Study

The study explored influence of outdoors and near work activities on myopia in students, aged between 13 to19 years, in Kakamega, Lurambi Sub County, both in schools situated in urban and rural setting in the area. The participants were regular domicile of that setting where the school was situated. Eye examination was done on the participants to elicit those with myopia and those without myopia. Structured questionnaires were employed as the main data collection tool.

1.9 Limitations

The use of questionnaires instead of direct observation could have contributed to recall bias since the participants had to give account on their involvement in outdoor activities and near work activities. This necessitated repeat of some questions while administering the questionnaire resulting to time consumption. This study focused on secondary school going students and may not have been a representation of the entire Kenyan population, although the age bracket of myopic population has been documented to be more prevalent in the age between 13 to 19 year contrasted with rest of the population. The use of analytical cross-sectional design may give us association, but association does not necessarily mean causation.

1.10 Conceptual Framework

Engaging or not engaging in outdoor activities and near work activities were the independent variables in the study. It is presumed that they had influence on myopia, although their direct relationship was not well understood (Ip *et al.,* 2019). Myopia was the dependent variable in the study, having or not having myopia was depended on engaging or not engaging in outdoor activities and near work activities. Genetics/parental myopia and social demographic factors such as age, gender and class of the respondents were the confounding factors. This means that they had an influence on having or not having myopia even though literature on their contribution to myopia is not properly established. Below is the conceptual framework developed by the researcher illustrating the factors that contribute to the development of myopia and have association with myopia. The conceptual framework below is by the researcher and it illustrates the factors that contributes to the development of myopia and have association with the myopia.

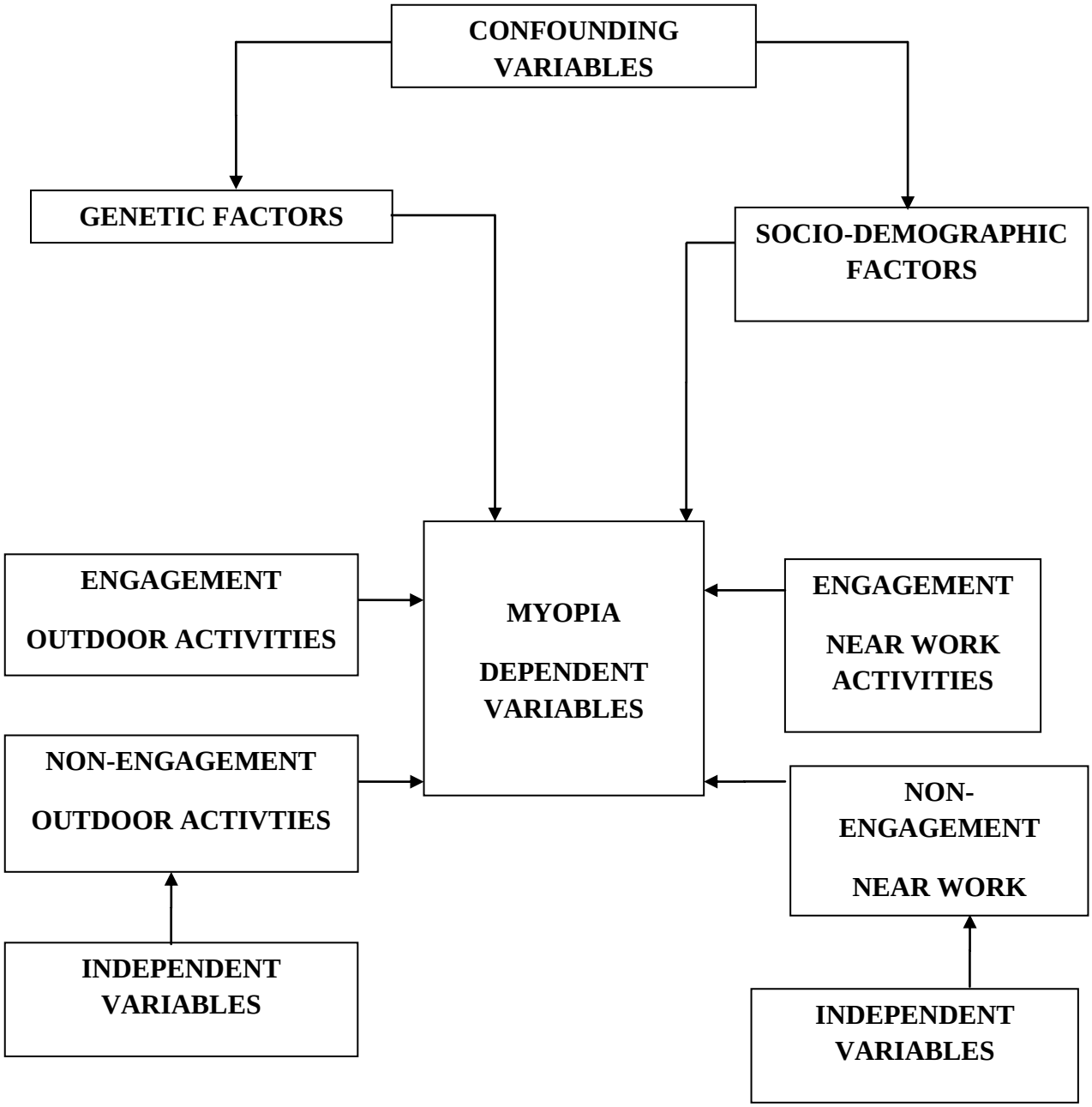

Figure 1.1: Conceptual framework

Source: Researcher, 2019

CHAPTER TWO

LITERATURE REVIEW

2.1 Prevalence of Myopia

According to Modjtahedi *et al.,* (2018), myopia is considered to be the most frequent ocular problem amongst adults and children. The pattern of prevalence and distribution of myopia worldwide is mostly dependent on the geographical and ethical distribution (Ma, *et al.,* 2018). Juvenile myopia, which is significantly credited to ecological factors and close to work, is considered to be more predominant and is on the ascent contrasted with congenital myopia (Myrowitz, 2012). This can be used to explain why myopia can be environmentally linked other than genetically linked. However, the connection between myopia and environmental factors is questionable, with some research papers reporting that myopia is environmentally linked. On the contrary, a few research studies found non-significant effects that relate to the environment on myopia (Huang *et al.,* 2018; Guo *et al.,* 2017; French *et al.,* 2013; Sherwin *et al.,* 2012: Lin *et al.,* 2017).

High rates of incidences and progression have been experienced in South East Asia with an estimate progression of 1Ds annually (Holden, *et al.,* 2015). The predominance experienced is approximately 80-90% as compared to the United States which experiences a predominance of 25% (Xu, *et al.,* 2005). A clear elucidation in the variance on prevalence between the two countries is yet to be established. Even so, some studies indicate that the environmental factors are the main contributors to the variance in myopia prevalence between United States and South East Asia (Ramamurthy, *et al.,* 2015;Lyhne,*et al.,* 2001;Zhang, 2015).

The most common and repetitive refractive error contrasted with the other refractive errors in Africa is myopia. It adds to about 58% of the total refractive errors cases (Koomson, *et al.,* 2013). In Africa, the dominance is estimated to be about 2.7% whereas in Kenya it is said to be 1.7%. The predominance of myopia in Africa has been low; some studies assert that this may be because of the schooling systems in Africa which are not as vigorous as compared to other states. However, this has not been academically established (Brittain, *et al.,* 2010). It is considered that the abrupt changes on myopia's prevalence cannot be credited on genetics because the gene pool cannot suddenly change. As a result, environmental factors tend to have stronger association to myopia as compared to genetics, even though a majority of these studies were systematically analysed (Ip, *et al.,* 2019;Tsai, *et al.,* 2009).

Females are considered to be more susceptible to myopia than males while prevalence is comparatively high in developed states than in the developing states (Muma, *et al.,* 2007). To add on, developing states deal with a high number of refractive error cases which go uncorrected, hence prevalence estimation becomes a challenge (Morgan *et al.,* 2018b).

There exists two categories of myopia such as school myopia or juvenile myopia and congenital myopia (Chan, *et al.,* 1996). School myopia is predominant than congenital myopia, justifying the impact of environmental aspects have on advancement and progression of myopia (Myrowitz, 2012). Studies show that the major causative factors in the onset and development of myopia are the environmental factors as compared to the roles of parental or hereditary factors (Huang *et al.,* 2018).

A research study carried out on the Alaskan Eskimos asserts that increased predominance of myopia in the population ensued due to the launch of modern mandatory schooling (van Rens & Arkell, 1991). The widely recognized environmental elements that initiate progression and onset or advancement of myopia have been discovered to be near tasks and outdoor activities (Ramamurthy *et al.,* 2015). It is asserted that predominance of myopia is increasing globally nearly half of the globe will be affected/infected with myopia by 2050 unless something is done to combat the rising pervasiveness (Bourne *et al.,* 2017). Although not all studies agree with environmental factors being the reason for the increase in prevalence (Hagen *et al.,* 2019).

2.2 Socio-Demographic Distribution of Myopia

It has been established that myopia steadily increases with age (Huang *et al.,* 2018). Myopia's pervasiveness in children rises significantly from 7 – 17 years in the East Asian populaces (Wu *et al.,* 2015). According to Fan *et al.,* (2019), the frequency of myopia as a refractive error is incomparable and it´s prevalence is believed to be 36.7% among children. The reason for the steady growth in the pervasiveness of myopia has been accredited to lag of accommodation that results in axial length elongation because of near related activities. It is supposed that the pervasiveness of myopia in preschool is lower as compared to school going children for this reason, although there is no consensus on the exact involvement of near work activities on myopia progression and development.

The correlation between the predominance of myopia and older age was positive. Also, it was established that children aged 11 years were more susceptible to myopia as compared to children aged below seven years, the occurrence of myopia has been found to be 144 per 1000 children going to primary school annually. The increase in

age correlated with the ever-increasing pervasiveness of myopia, recording the highest prevalence among children aged 11 years and above (Saxena *et al.*, 2017). The mean rate of myopia progression in childhood is estimated to be roughly 0.5 annually (Vasudevan *et al.,* 2014). Approximately, 75% of teenagers have their refractive errors become stable when they get to 16 or 17 years of age. For those whose refractive error don't stabilize, the progression frequently stays into their 20s or 30s (Metsing *et al.,* 2018). The estimation of prevalence of myopia is about 3% amongst children aged between 5 and 7 years, while the 8% is allocated to children aged between 8 and 10 years. The prevalence for children aged between 11 and 12 years is 25% while those aged between 12 to 17 (adolescents) is 25% (Vitale *et al.,* 2008).

In Ghana, a study among children aged between 7 to 17 years established the rate of recurrence for myopia's distribution to have a linear progression pattern with age. In addition, myopia and astigmatism was elevated in the metropolitan setting with a two percent disparity (Koomson *et al.,* 2013). The predominance of myopia was established to be at 10.2% between the ages ranging from 12 to 15 among Kenya's urban group. (Nyamai, 2016). This was higher compared to the rural group whose prevalence was at 1.7 percent (Nzuki, 2004). Myopia pervasiveness contrasts with race, sex and age, growing at least through puberty, and is present in 1% of children at age five, growing to 8% at 10 years and approximately 15% at 15 years (Chiang *et al.,* 2019). From the above stated studies, it can be established that the rate of myopia in numerous population groups increases with age. In our population, the studies done by Muma *et al.,* (2007) and Nzuki *et al.,* (2004) among the age group of 12-15 years in rural and urban settings differed in their findings. The predominance of myopia amongst children aged between 12-15 years in urban parts of Kenya was

10.2%, and was the highly frequent refractive error in this age group (Nyamai, 2016). However, this was not the case for the same age group in rural Kenya where studies established that myopia was the second most widespread refractive error at 1.7% after hypermetropia at 3.2% (Nzuki, 2004). Published data on the patterns of refractive error among ages 16-19 years in Kenya was lacking.

Globally, the predominance of myopia is anticipated to grow from 27% of the entire populace in 2010 to 52% by 2050 (Bourne *et al.,* 2017). This corresponds to a 2.6-fold increment in the number of individuals living with myopia, creating chance for foreseen escalation in the entire population. If the expanding predominance of myopia is left unattended, a comparative increment in unhandled refractive error can be anticipated. These anticipations are founded on preservationist presumptions and given the published relationship amid the education levels and myopia; improved provision of education may possibly significantly expand these developments. Besides, uncorrected distance refractive error has been assessed to result in a worldwide shortfall of throughput of US$ 202 billion (Holden *et al.,* 2016), which can moreover increment in the event that there's a critical increment in uncorrected myopia (Kumasi, 2015).

Gender has also been found to have an influence on myopia (Malaysia, 2005). In Israel, a study was carried out and it established that schoolboys attending orthodox sponsored schools were most likely to have myopia. This was a contrary outcome to the results indicating that girls attending religious schools had a low probability of developing myopia. (Saw *et al.,* 1996). This revelation was believed to be because of the time and devotion put in studying in orthodox schools as compared to common schools. In as much as this is the case, most researches assert that a majority of research done have continuously established myopia predominance to be more in

boys than girls (Rudnicka, *et al.,* 2016). Also, that transient myopia leads to near related activities as opposed to near related activities causing myopia (lin *et al.,* 2017). Introduction to thorough teaching methods\techniques and prolonged studying time children spend while in school has been implicated in the heightened risk of the growth of myopia (Ip *et al.,* 2019). However, it still doesn't illuminate why myopia is highly predominant in boys than in girls.

Myopia has been found to correlate with higher education level as well as higher academic achievements(Mountjoy *et al.,* 2018). According to studies, myopia was highly prevalent in Chinese in Singapore as compared to Chinese in Sydney because of the competitive schooling system in Singapore compared to Sydney (Rose *et al.,* 2008). The rationale of the association between higher education level and myopia is due to the axial length elongation found to be associated with higher education (Guo *et al.,* 2017). Higher educational level is a surrogate of near work and does not have association with myopia (Lu *et al.,* 2009).

2.3 Level of Outdoor Activities and Myopia

Out-of-doors activities have been investigated to ascertain their influence on myopia in the past decade. In Singapore, the prevalence is 28% while a study in Sydney found a prevalence of 3.3% (Rose *et al.,* 2008). The main factor causing the disparity is time spent participating in outdoor activities, it estimated that youths in Sydney spent 13.8 hours participating in outdoor activities while Singapore youths spent 3.0 hours a week (Ip, Saw, *et al.,* 2008).

Children that devote substantially few hours in a week being outdoor or performing sports activities are likely to be myopic in comparison to those that spend a lot of time participating in open-air activities (Pan, Ramamurthy, & Saw, 2012). Guggenheim *et al.*, (2012) established that the time spent out-of-doors was prognostic of occurrence of myopia self-reliantly on the corporeal activity level. The percentage of hours in a week spent outdoors was linked with a 2% reduction in the odds of having myopia, following adjustment for cofounding (Sherwin *et al.*, 2012).

Myopic students have been found to spend less time outdoor compared to non-myopic students (French *et al.*, 2013). Although Guo *et al.*, (2016) believed that there is no statistical significance in the difference in hours spent engaging in outdoor activities among myopic and non-myopic.

Axial length has been meaningfully correlated with a reduced amount of time spent outdoor and additional time spent indoor studying (Wu *et al.*, 2018). A research study done by Rose et al (2008) amongst Chinese children argued that there was low pervasiveness of myopia in Chinese children brought up in Sydney in comparison to those raised in Singapore. This was because Chinese children brought up in Sydney spent a considerable amount of time outdoor unlike Chinese children in Singapore. Also, early educational pressure in Singapore explained the difference in prevalence between Singapore and Sydney. This is also in line with Guggenheim *et al.*,(2014) study which illustrated that less physical activity and less time spent outdoor can be associated with incidents of myopia, with time outdoor activities contribute more effects compared to physical activities. Their conclusion was that time spent outdoor was a good predictor of incident of myopia independent of the physical activities. Outdoor activities were found to have a protective effect while other studies found

myopia to have association with outdoor activities (Mutti, *et al.,* 2002;Longmuir, *et al.,* 2014). Jones *et al.,* (2007) argued that outdoor activities may be associated with myopia irrespective of the ethnicity.

2.4 Level of Near work Activities and Myopia

Near work can be defined as activities that are done at a short working distance (at around 50cm and below) while intermediate activities are activities that are done at 75cm to 100cm and they include reading, perusing (homework and composing), and computer use or videogames playing, or TV viewing(Gao *et al.,* 2017). Due to tall visual requests of near work in schools, juvenile myopia has been associated with near work. There are no clear elaborations so far on the relationship between near work and myopia but extended acquittance between hyperopic defocus and near work have been established. This acquittance is from the accommodative lag which invigorates the top eye ball stretching leading to myopia astigmatism progression or axial myopia (Ip *et al.,* 2008). Increased time spent studying and high education levels within educational institutions have been connected to increased chances of development and progression of myopia (Williams *et al.,* 2015). In further conducted studies, ceaseless time and close studying/perusing were used to measure the impact of near work. It has been figured out that students who studied persistently for about 30 minutes or more are likely to develop myopia in comparison to those who study for less than 30 minutes ceaselessly. The probability of children developing or having myopia is 2.5 times likely since they are close to near work at a remoteness of 30cm or less as compared to those who operate on larger distances. Lengthier time perusing for fun and perusing at a remote expanse closer than 30cm is additionally connected to increased myopic refractions (Cordain *et al.,* 2018).

2.5 Relationship Between Near work activities, Outdoor Activities and Myopia

2.5.1 Relationship between myopia and out-of-doors activities

Investing additional time in open air diminishes the probability of being myopic and open air exercises are not complementary of performing near related activities (Rose, *et al.,* 2008). They need to be handled as in depended components that translates to the progression and development of myopia. Reduced time in sporting action contributes less on juvenile myopia (Guo *et al.,* 2017). Open-air activities in the course of class recess are an effective way of preventing myopic shift and myopia onset amongst the elementary school learners in metropolitan areas (Holden *et al.,*2014). Wu *et al.,* (2012) believed in the adjustment of scholastic policy throughout the educational structure in hindrance of myopic swing. High pervasiveness of myopia in Chinese children in Singapore has been contrasted to the low predominance of myopia in Sydney (French *et al.,* 2013). However, this can be because of the differences in ethnicity and not necessarily because of outdoor activities.

The justification for the high pervasiveness of myopia has been ascribed to less outdoor activities. Out-of-doors activities are considered to be an important shielding factor counter to myopia and it is correlated to the educational system, though most studies have not found outdoor activities to have relationship with myopia (Sherwin *et al.,* 2012). Outdoor activities are believed to be clinically significant and not statistically significant (Wu *et al.,* 2012). The educational system intermediation is understood to be an immediate and practical tactic in confronting the surging predominance of myopia, since children spend most of their time in schools (Guo *et al.,* 2017).

The basic instrument of which outdoor exercises impact myopia onset and development has not been well elaborated for understanding so far (Morgan & Rose, 2019). Animals' research has established that increased light levels or rapid luminance fluctuations increases the emission of dopamine. This is considered a visual inhibitor development factor in the advancement of myopia, thus repressing myopia progression and development(Vagge *et al.,* 2018). Myopic parents sometimes may create a myopigenic environment to their children hence this may have a contributing factor to myopia onset and progression (Saxena, *et al., 2*015).

2.5.2 Relationship between myopia and near-work activities

Previous research studies have unearthed a correlation between near related activities and myopia, stating that near related activities can result to myopia (Ip *et al.,* 2019; Rose, Morgan, Smith, *et al.,* 2008; Vagge *et al.,* 2018). However, most of these studies were done on Caucasians and some were systematic review.

Despite the link between near task activities and having myopia, some researchers argue that near task activities is as a result of having myopia other than a causative effect on myopia. This is because myopes have their world near them since they have the clear near vision compared to distance vision (Lin *et al.,* 2017).

Students who perform significant amount of near work are likely to have myopia as compared to those who do not participate in significant amount of near work (Huang, *et al.,* 2015). The number of books read per week has an association with myopia, with children engaged in a lot of reading having myopia while those that read fewer books being non-myopic. Saw, *et al.,* (2002) found that children with sophisticated myopia read more books per week compared to the non-myopic, with the odds ratio of higher myopia for reading more than two books per week being 3.15 (95% CI,

1.96–5.04). Thus, books read per week was believed to be an independent risk factor to myopia. In the study, student who engaged in reading more than 2 hours per day had odds of 1.50 (95% CI, 0.87–2.55) developing myopia. Students with extra classes were twice as likely to have myopia, while students that used computers were also likely to have myopia.

Those with myopia engage in more time reading and studying compared to the non-myopic. The near activities that have been found to relate with myopia are perusing or studying for school assignments day by day, perusing for pleasure day by day, utilizing computer week by week, watching tv week by week, and playing electronics week after week, compared with students. Non myopes have been found to have a longer watching distance or reading distance than those who are myopic. (Mutti *et al.,* (2002) exhibited that studying for pleasure for more than 2 hours expanded the probability of having myopia. Myopia was higher in those engaging in more than 2 hours reading for pleasure, although the positive association was only found in boys and not girls. The study also found positive association between time spent watching television and playing video games with myopia. Similarly, Ip et al (2008) found myopes to spend more time reading compared to non-myopes. This is also similar to (Saxena *et al.,* (2015) that found myopia to be higher in those involved in reading for more than 5 hours a week.

Guo *et al.*, (2016) found out that students who study more than 2 hours per day, read for delight more than 2 hours every day, utilized computer more than 2 hours on a weekly basis, watched television more than 2 hours per week, played with gadgets more than 2 hours per week, and studied for close or more than 25 centimetres, as well as watched television closer than 3 meters, the proportions of myopia group

were more noteworthy than no myopia group, respectively. In addition, distance of near work has been found to be associated with myopia, although some studies only consider it as a risk factor for myopia (Wu *et al.*, 2015). Myopic students have been found to have a closer distance for reading or closer distance for watching television than non-myopic students, that students whose reading distance is shorter than 25cm were likely to have myopia. This is consistent with Sydney that showed that reading close (30cm) autonomously boosted the risk of experiencing myopia in children (Rose *et al.*, 2008b).

2.6 Summary of Literature Review

Although outdoor activities and near related activities are shown to be an important factor in myopia, there association and link to myopia is not well understood, with some researchers insisting that their role on myopia is clinically significant other than statistically significant. Near related activities are also shown to be transient of someone having myopia other than a causative effect on myopia (Li *et al.*, 2015). Outdoor activities are an important factor in myopia control though some researchers argue that they have no association with having myopia. (Ramamurthy *et al.*, 2015).

The interaction of outdoor activities and near related work and the role they play on someone having myopia has not been well documented. It is believed that predominance of myopia is on the upswing, with an estimation of half of the global population having myopia by 2050 (Morgan & Rose, 2019). Myopia has also been shown to be high in adolescents yet studies on risk factor especially (outdoor activities and near work activities) and data on pervasiveness of myopia in Kenya by extension Lurambi sub county is scarce (Barasa *et al.*, 2012). Thus, the study was done to establish the influence of out-of-doors and near related activities on myopia

among students going to secondary schools in Lurambi Sub-County. The study was also to establish comparison on the different outdoor and near related activities that those with myopia and those without myopia are engaged in.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The research study was carried out in Lurambi Sub-County Kakamega, Kenya. Lurambi Sub-County houses both urban and rural schools and it is the most cosmopolitan sub-county compared to the rest of the sub counties in the country. It is one of the sub counties in Kenya that has the highest number adolescents (KNBS 2019). This makes the area ideal for the study since myopia has been found to be more prevalent in adolescents compared to younger age (Ho & Nallasamy, 2017). It also houses Masinde Muliro University of Science and Technology which is the only institution with the state of art equipment and facility in terms of management of optometry patients.

Lurambi Sub-County has 22 secondary schools. It is one of the most multicultural sub-counties situated in the western part of Kenya. It's inhabited by people from various parts of the state and diverse ethnic groupings. Also, Lurambi subcounty is rated as one of the sub counties that is highly populated with youths contributing the highest percentage to the population (KNBS, 2019).

3.2 Study Design

An analytical cross-sectional study design was adopted. This method was used because it explored the relationship between different variables (outdoor activities, near work activities and myopia) in their two natural settings as they occurred. It measures both risk and outcome at one point in time and is able to give prevalence of the outcome at the same time.

3.3 Study Population

The study's target population were 7,400 students who resided or attended schools within Lurambi Sub County. The study particularly targeted secondary school-going students aged 13 to 19 years, with and without myopia, resided both in rural areas and urban areas of Lurambi Sub County and attended schools in Lurambi Sub-county.

3.4 Inclusion and Exclusion Criteria

3.4.1 Inclusion criteria

All study participants were drawn from schools within Lurambi Sub County, they had to be regular domicile at that particular place the school was situated and had to give their consent or assent.

3.4.2 Exclusion criteria

Participants who had other ocular pathologies that were presenting as myopia, but not myopia were excluded from the study. Examples of these conditions were cataract, participants who had uncontrolled diabetes and other pathological conditions.

3.5 Sample Size Determination

The lowest possible sample size, n, for this research study was derived using the formula below (Yamane., 1967);

Where, n = minimum sample size

$$n = \frac{N}{1 + Ne^2}$$

where n is sample size, N is underlying population size which, in this study, will be 7400 and e is e=0.05, 95% confidence interval.

$$\frac{7400}{1+18.5}$$

$$\frac{7400}{19.5}$$

=379.49 plus 10% Attrition ≈ 420 students

Hence, minimum size, n, for the study = 420 subjects.

3.6 Sampling Techniques

This study selected participants from Lurambi Sub County. Sampling was done in two stages. The multistage sampling techniques were:

Stage 1: Purposive sampling of 2 clusters, 1 of rural schools and 1 in urban schools

Stage 2: Proportionate sampling technique.

3.6.1 Purposive sampling

This involved purposive selection of public day secondary schools in Lurambi sub-county. This was due to unclear information on private secondary schools in the sub county. Also, other private secondary schools were operating without the knowledge of the government. To add on, there were many public secondary schools in the sub county, both in rural and urban, accommodating children from different economic levels hence providing a heterogeneous population suitable for the study.

3.6.2 Proportionate sampling technique

The 22 schools in Lurambi Sub County were classified into two; urban schools and rural schools. The urban schools were identified by their locality. Schools found within Kakamega Municipality of Lurambi Sub County were classified as urban schools while those that were found in rural parts of Lurambi formed the second cluster- rural schools. The two clusters had a total of 22 secondary schools with a 7,400 approximation on students' enrolment in 2018.

Considering the disproportionate student numbers in the schools, proportionate sampling technique was used to make sure that every student in all the schools had the same chance of selection. To achieve this, the students were grouped in equal groups and each group was labelled. The grouping was done on an increasing additive order. Computer generated random system was used to select the four groups for screening; two in the rural group and two in the urban group (http://www.random.org/integers/).

Required minimum sample size from the sub-county = 420 students

Required minimum sample size per school = 420/22 = 19 ≅ 20 (to nearest 10)

Hence, based on 9.1% prevalence of myopia, we have = 20/0.091 = 219.78 ≅ **220** (to the nearest 10). This implies that based on increasing additive order (cumulative frequency), the entire student population was grouped, with each group having a class size of 220 ± 20 students. The essence of ± 20 deviation was to ensure that no school fell into two groups. All schools in the randomly (computer-generated random) selected group (in each cluster) was included in the study.

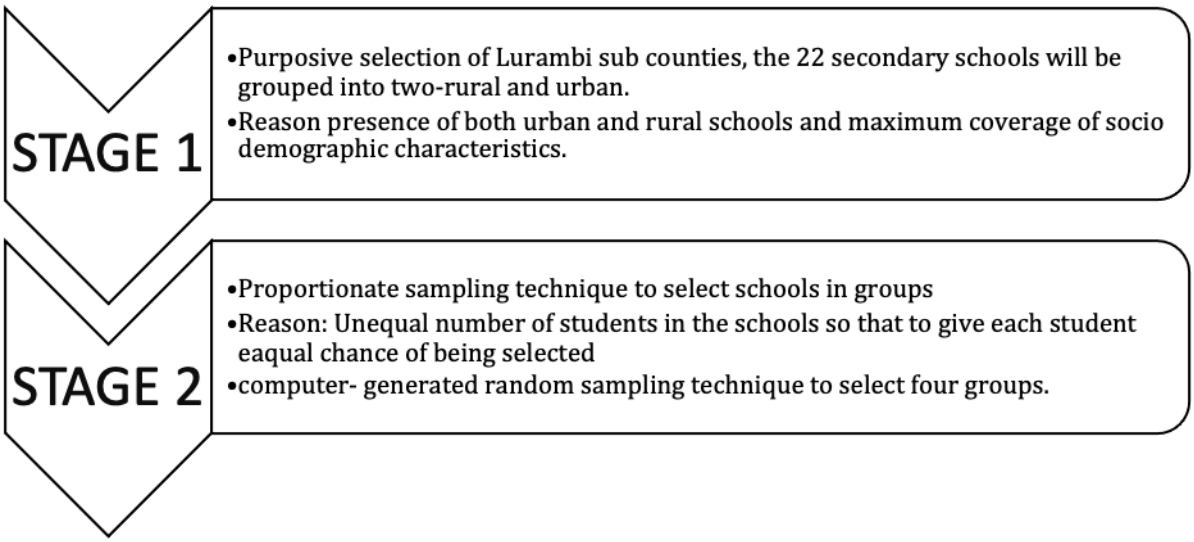

Figure 3.1 Multistage sampling techniques

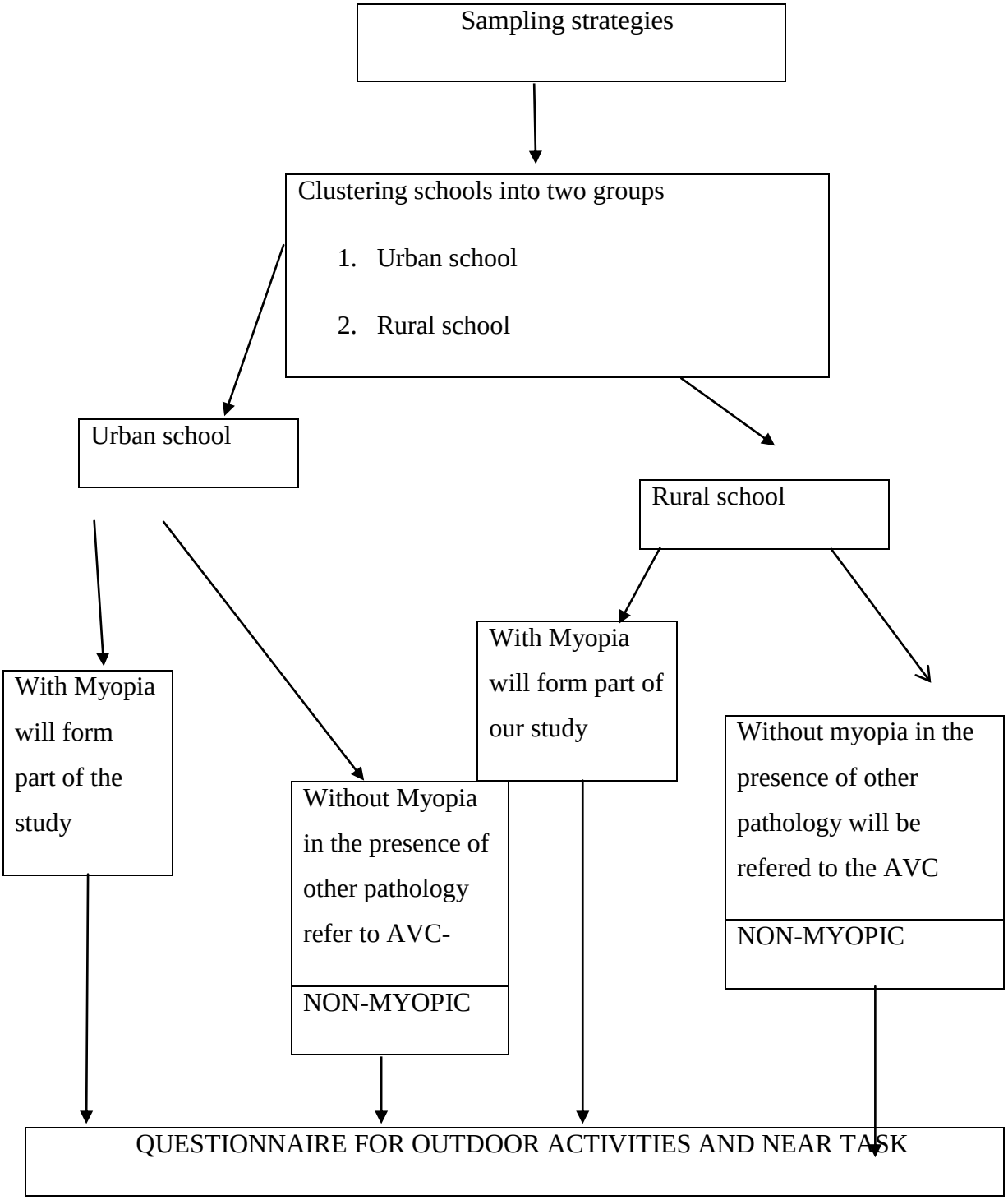

Figure 3.2 Sampling strategies

3.7 Data Collection Tools

Ocular examination was done by the use of log Mar visual acuity charts, slit lamp for anterior segment examination, Keeler streak retinoscopy for refraction and direct ophthalmoscope for fundoscopy examination. A structured questionnaire was adapted from Sydney Myopia Study (SMS) (Rose *et al.,* 2005), (available at http://www.cvr.org.au/sms.htm). The questionnaire was divided into three parts. The first part was the sociodemographic distribution of the study participants consisting of participants' gender, age, place of residence and current class of the respondent.

The second part of the questionnaire entailed questions revolving around outdoor activities. They included participation in sporting and outdoor games, time spent participating in sporting activities, time spent playing outside the classroom and time spent outside the house. The participants were expected to provide hours spent on sporting, frequency of participation in outdoor activities as well as hours spent playing with neighbors. These questions were tailored to revolve around outdoor activities. Questions on the near work activities formed the third part of the questionnaire. These activities included whether the participants were involved in extra revision classes, the hours spent on computers, whether the participants spent plenty of time reading story books or playing video games on the phone and whether the participants held books closer to their eyes while reading. In addition, the respondents were supposed to give the number of classes they attended every day, the length of extra revision classes taken every day, distance they sat or stood while watching television, hours spent on computer every day, hours spent reading story books or newspapers, distance of the reading material while reading and hours spent playing games on the phone.

3.8 Data Collection Techniques

Since the study was among adolescents and minors, written consent notes were issued to the legal guardians and adolescents. Minors' written consent was issued through headteachers before conducting an in-depth assessment of the study population. The consent contained the full content of the research study. The steps involved in the assessment were as discussed below;

All participants of the study were tested for visual acuity, including those who had the visual acuity of 0.1 log Mar (6/9 expressed as Snellen's acuity), and worse was subjected to pin hole to determine if the refractive error was the main cause for the individual's reduced visual acuity. Persons with visual acuity better than 0.0 log Mar (6/6 expressed as Snellen's acuity) were classified as non-myopic. Those that had eye conditions other than myopia were referred to MMUST academic vision Centre for subsequent eye treatment.

Slit lamp examination, using Appasamy slit lamp and direct ophthalmoscopy, using Keeler professional direct ophthalmoscope was done on participants with presenting visual acuity of 0.1 log Mar (6/9 expressed as Snellen's acuity) and worse in any of the eyes to rule out any non-refractive ocular pathology. The participants found with other ocular pathology were excluded from the study. They were, however, refereed to MMUST Academic Vision Centre or Sabatia Eye Hospital (SEH) due to proximity and being the only eye centers in Western Kenya.

Children not found with any active ocular pathology underwent cycloplegic refraction using cyclopentolate and where cycloplegia was not possible, non-cycloplegic normal retinoscopy was performed while controlling for accommodation. This process was done using a Keeler streak retinoscope to determine if the refractive

error was myopia. Myopia was defined as those with refractive error less than or equal to -0.50Ds. Study participants that experienced other refractive error besides myopia were counselled on the benefits of spectacle correction in the presence of their legal guardian. They were also removed from the study group and referred to Masinde Muliro University of Science and Technology Academic Vision Centre (MMUST-AVC) for further analysis and spectacle correction at a fair cost.

The study participants discovered to have myopia formed part of inclusion criteria and were included in the study. Those that were myopic astigmatic, spherical equivalence was calculated and they formed part of the study. Questionnaires were distributed to help collect outdoor activities information and near tasks from the participants. The questionnaires were also distributed to collect the parental role information, contact information and basic socio-demographic data from the participants who had qualified for the inclusion criteria.

3.9 Test for Validity

The questionnaire was adapted from Sydney Myopia Study (SMS) (Rose *et al.*, 2005) (available at http://www.cvr.org.au/sms.htm). It underwent face validity through presentation to myopia experts in the field and season scholars who have conducted research around myopia. They determined whether the questions in the questionnaire covered all the variables of the study and their feedback was used to improve the questionnaire. The questionnaire was further subjected to pre-test where it was administered to a sample with the same characteristics as the study population. The sample was 10% of the study sample and were students from Kirembe secondary school in Kisumu. The response time was taken, and adjustments were made based on the feedback from the pre-test.

3.10 Test for Reliability

This is the ability of the assessment tool to produce consistent results. To achieve this, all the study participants were subjected to the same questionnaire and the examination was done by the same clinician. The participants were subjected to the questionnaire twice to ensure repeatability of their responses. To strengthen the reliability of the questionnaire, Cronbach's alpha was used at reliability coefficient of 0.81, questions with higher coefficient were accepted in the study.

3.11 Data Management and Security

Data security and proper management guaranteed the confidentiality needed in this study. The first measure was storing the questionnaire sheets in a locked cabinet to avoid damage and access by unauthorized people. According to Speed (2019), the top data security threats come from negligence. Thus, immediate action was taken to ensure that there is no room for the data to be accessed by unauthorized people due to negligence.

Secondly, user authentication was used to prevent unauthorized persons from accessing the information. Although the information about the participants was collected by printed copy, it was transferred into a digital format and stored in a computer. Thus, setting a one-factor authentication in the form of a strong password essential.

3.12 Data Analysis

The data collected was entred into a database designed Ms-Excel 2016. It was then exported into SPSS version 25. The data was then analyzed by the use of suitable statistical tools.

Before actual analysis and exportation into SPSS version 25 for analysis, the data was properly cleaned. Normality testing was done by the use of Kolmogrorov – Smirnov at a significant level of $\alpha = 0.05$. Prevalence and socio-demographic distribution of myopia was analysed in terms of gender, age , level of education or grade (hereby reffered to as 'form'). Myopia prevalence was the dependent variable while gender, age and level of education were independent variables. The statistical tools that were used were descriptive statistics including proportionate and average as well as inferential statistic which included chi- square to test for the association. Level of outdoor activities and near work activities involvement were analysed by proportionate descriptive statistic, where outdoor activties and near work activties were independent variables and myopia a dependent variable. The relationship between outdoor activities and myopia were established by the use of logistic regression. Similarly, near task activities were determined by logistic regression. A p-value of equal to or less than 0.05 was considered to be significant at 95% confidance interval.

Table 3.1 Data Analysis and Presentation

OBJECTIVES	VARIABLES		STATISTICAL TOOL	DATA PRESENTATION
To determine the prevalence of myopia in secondary school students in Lurambi Sub-County.	Myopia		Descriptive Statistic (proportion)	Pie chart
To determine the socio demographic distribution of myopia in secondary school students in Lurambi Sub-County	Independant Gender,age, class	Dependant Myopia	Descriptive Statistic (proportions) Inferential Statistic (Chi-square)	Tables
To estimate the level of outdoor activities among myopia and non-myopic secondary school students in Lurambi Sub-County	Outdoor Acivities	Myopia	Descriptive Statistic (proportions)	Tables
To establish the level of near related activities among myopic and non-myopic secondary school students in Lurambi Sub-County.	Near Work Activities	Myopia	Descriptive Statistic (proportion)	Tables
To determine the relationship between outdoor activities, near work activities and myopia amongst secondary school students in Lurambi Sub-County.	Outdoor actvties Near-related activities	Myopia	Logistic Regression	Tables

3.13 Logistical and Ethical Consideration

Before commencement of the study, ethical clearance which is a requirement before carrying out any study, was obtained from the Institution of Ethics Review Committee (IERC) of Masinde Muliro University of Science and Technology. The precepts of the Declaration of Helsinki were observed all through the study.

To carry out free eye screening among students from the selected group of schools, permission was obtained from the health officers, district and county commissioners, education and specific school heads and principals.

Respect for Autonomy

Participant's right to autonomy was protected by issuing an informed consent. The purpose of the study was explained to the parents and any expected benefits to the subjects was explained prior to the study. They were allowed to make free and informed decisions to voluntarily participate in the research. The study guaranteed subjects a right to refuse to participate as well as to opt out in case they felt threatened in any way. This ensured that personal liberty and veracity was protected.

Confidentiality and Privacy

Private information obtained from the participants was protected against disclosure to any unauthorized person. The information was only applicable within the research setting. This was achieved by ensuring that the hard copy research records were stored in locked cabinets and locked rooms with limited access while electronic data was kept in password protected computers. To ensure privacy, there was no collection data that could give participants identity. The participant's identity information was coded to ensure that they could not be linked to personal responses thus ensuring anonymity.

Beneficence

The research ensured maximum benefit in order to promote the welfare of participants. During examination, affected children received adequate correction and vision therapy as needed while those that required follow ups were referred to the academic vision clinic for further management.

Non- Maleficence

The participants were protected from any kind of physical and emotional discomfort or harm. This was done by ensuring that the participants were treated with respect and dignity. Equality and fairness were maintained in all steps to protect subjects with emotional discomfort.

Only trained personnel with required skills and knowledge were allowed to examine participants to avoid imposing a careless risk of harm to participants. During the examination, it was ensured that the procedures done did not cause any harm to participants.

CHAPTER FOUR

RESULTS

4.1 Introduction

The current study sampled a total of 733 students, out of which 326(44.5%) were females and 407(55.5%) were males. 383(52.3%) were from the rural area while 349(47.6) were from the urban setting. Majority of the participants 520(70.9%) were aged between 15 -18 years, this was followed by above 18 years who included 153participants (20.9%) and the least were 11 – 14years who were 60(8.2%) as shown in *table 4.1*.

Table 4.1: Demographic of the study population

		Frequency	Percent
Gender	Female	326	44.5
	Male	407	55.5
Domicile	Rural	383	52.3
	Urban	349	47.6
Age	13-14 years	60	8.2
	15-18 years	520	70.9
	above 18 years	153	20.9

4.2 Prevalence of Myopia

Out of the 733 students who participated in the study, the occurrence of myopia in males 29(52.7%) and in females 26(47.3%) was not statistically significant. Prevalence was found to be 7.5% as shown in *figure 4.1*.

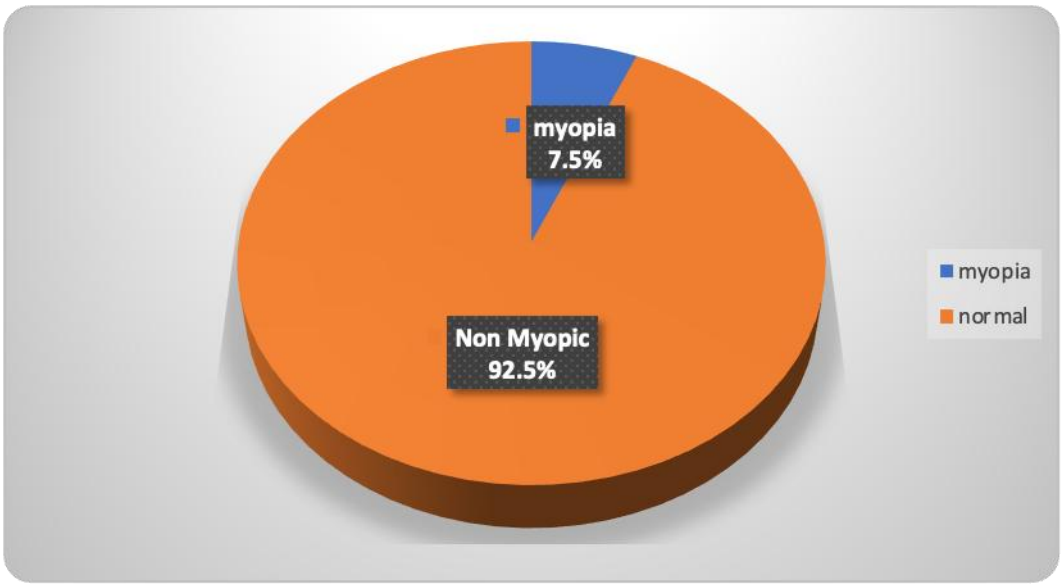

Figure 4.1: Prevalence of myopia

4.3 Social Demographic Distribution of Study Participants

The socio demographic characteristics, as shown in the *Table 4.2*, found no correlation between gender and myopia; (p = 0.572). Males constituted just over half of those who were myopic which was 29 (52.7%) while 378(55.8%) non-myopes in the study were males. The 15-18-years was the dominant age group and there was no association between age and myopia (p= 0.926). In addition, the majority of the myopic participants came from an urban setting leading to 49 students (87.3%), although there was no association between place of residence and myopia p = 0.381. There was no association between the school class group of the participants and having myopia (p = 0.207). Most of the participants who were myopic were form one, two and four where each class had 15 students (27.3%). There was an equal distribution of myopia in terms of class of the respondents.

Table 4.2: Cross Tabulation of Socio-Demographic factors with myopia

Socio-Demographic		Non-Myopic n (%) n=678	Myopia n (%) n=55	p-Value
Gender	Male	378(55.8)	29 (52.7)	0.576
	Female	300(44.2)	26 (47.3)	
Age	13-14 Years	55(8.1)	5 (9.1)	
	15-18 Years	482(71.1)	39 (70.9)	0.926
	Above 18 Years	141(20.8)	11 (20.0)	
Residence of the respondents	Urban	300(44.3)	49 (89.0)	0.381
	Rural	377(55.7)	6 (11.0)	
Current Class of The Respondent	Form One	308(45.5)	15 (27.3)	
	Form Two	173(25.5)	15 (27.3)	0.207
	Form Three	111(16.4)	10 (18.1)	
	Form Four	87(12.7)	15 (27.3)	

Data are presented as frequencies (n) and percentages (%), categorical variables were compared using Chi-square test. Significant set at $p \geq 0.05$.

4.4 Level of Involvement in Outdoor Activities

The findings in *table 4.3* show that 431(63.6%) and 27(49.1%) of non-myopic and myopic students respectively took part in sporting and outdoor activities most days of the week. Of these, 407(60.0%) of non-myopic and 4(7.3%) of myopic reported spending 3 to 4 hours per day on outdoor activities as shown in *table 4.4*. When asked if they spent plenty of time playing outside the classroom and in the field at school every day, majority of the myopic students indicated that they did not. Of those who reported playing outside the classroom, 493(72.7%) of the non-myopic and 1(1.8%) of myopic reported to doing so for 1 to 2 hours as shown in *table 4.4.* Similarly, 30(54.6%) of the myopic and 278(41.8%) of non-myopic said they did not spend plenty of time outside the house playing with friends and neighbors during weekends.

Table 4.3: Level of Outdoor Activities among myopic and non-myopic

Outdoor activities		**Non-Myopic n (%)**	**Myopic n (%)**
Participating in sporting and outdoor games	Yes	431(63.6)	27(49.1)
	No	234(34.5)	25(45.5)
Time spent participating in sporting activities	Yes	308(45.4)	18(32.7)
	No	296(43.7)	33(60.0)
Time spent playing outside the classroom	Yes	431(63.6)	9(16.4)
	No	222(32.7)	46(83.7)
Time spent outside the house	Yes	357(52.7)	24(43.7)
	No	278(41.8)	30(54.6)

Data are presented as frequencies (n) and percentages (%)

Table 4.4 Frequency of involvement in outdoor activities

Reported Frequency of Duration of Activities		
ACTIVITIES	**Non- Myopic N (%) n= 678**	**Myopic n (%) n= 55**
Hours spend on sporting		
< 1 hour	98(14.5)	42(76.4)
1 to 2 hours	75(10.9)	4(7.3)
3 to 4 hours	407(60.0)	4(7.3)
> 4 hours	98(14.5)	5(9.1)
Frequency of participation in outdoor activities		
> a day	173(25.5)	20(36.4)
once a day	24(3.6)	24(43.6)
once a week	148(21.8)	11(20.0)
> every day	333(49.1)	0(0.0)
Hours spent playing outside the classroom		
< 1 hour	0(0.0)	37(67.3)
1 to 2 hours	493(72.7)	1(1.8)
3 to 4 hours	49(7.3)	9(16.4)
> 4 hours	136(20.0)	8(14.5)
Hours spent playing with neighbours		
1 to 2 hours	62(9.1)	39(70.9)
3 to 4 hours	505(74.5)	8(14.5)
> 4 hours	111(16.4)	8(14.5)

Data are presented as frequencies (n) and percentages (%).

4.5 Level of Students' Involvement in Near Work Activities and Myopia

Most of the students who were myopic 40(72.8%) and non-myopic 74(11.0%) reported to having extra revision classes often during the week. Out of these, more than half of the non-myopes 395(58.2%) and myopes 30(56.4%) had 6 classes and more as shown in *table 4.6*. Nearly half of the myopes 31(56.4%) indicated that they sat less than 3 meters to watch television while 197(29.1%) of the non-myopes reported the same. The findings also show that most students who were non myopes 443(65.4%), and myopes 40(72.7%) did not use computers much. but rather spent most of their time reading. In the same regard, 209(30.9%) of non-myopes and 38(69.1%) of myopes agreed that they always held books closer to their eyes to a proximity of 10 to 25cm when reading. The findings further show that few of the students who are non-myopic 37(5.4%) and most of those who were myopic 43(78.2%) spent more than 4 hours playing on their phones as shown in *Table 4.6*. These data are summarized in *Table 4.5* and *Table 4.6*.

Table 4.5: Level of involvement in Near Work Activities among myopic and non-myopic

NEAR WORK ACTIVITY		Non-Myopic n (%)	Myopic n (%)
Extra/revision classes	Yes	74(11.0)	40(72.8)
	No	546(80.6)	12(21.8)
Sit/stand less than 3 meters to watch TV	Yes	197(29.1)	31(56.4)
	No	370(54.6)	21(38.2)
Long hours on the computer	Yes	172(25.5)	14(25.5)
	No	443(65.4)	40(72.7)
Long hours reading story books	Yes	184(27.2)	33(60.0)
	No	480(70.9)	20(36.4)
Bring the books very close	Yes	209(30.9)	38(69.1)
	No	444(65.5)	14(25.4)
Plenty time playing games on the phone	Yes	332(49.1)	27(73.5)
	No	283(41.8)	25(45.4)

Data are presented as frequencies (n) and percentages (%)

Table 4.6: Frequency of Near Work Involvement

Self-Reported Estimate of Quantity of Activity Near Work Activity	Non- Myopic n=678 (%)	Myopic n=55 (%)
Number of classes attended every day		
1 to 3 classes	160(23.6)	10(18.2)
4 to 6 classes	123(18.2)	15(27.3)
> 6 classes	395(58.2)	30(54.5)
Length of extra/revision classes taken daily		
< 1 hour	407(60.0)	2(3.6)
1 to 2 hours	123(18.2)	1(1.8)
3 to 4 hours	111(16.4)	34(61.8)
> 4 hours	37(5.4)	13(23.6)
Distance from sitting/standing point to TV		
≥ 1 meter	111(16.4)	24(43.6)
2 to 3 meters	185(27.3)	14(25.5)
> 3 meters	185(27.3)	7(12.7)
Not sure	197(29.1)	10(18.2)
Hours spent on computer every day		
< 1 hour	38(5.6)	3(5.5)
1 to 2 hours	37(5.5)	5(9.1)
3 to 4 hours	444(65.5)	34(61.8)
> 4 hours	159(23.4)	12(21.8)
Hours spent on reading story books/newspapers		
1 to 2 hours	567(83.6)	2(3.6)
3 to 4 hours	62(9.1)	2(3.6)
> 4 hours	49(7.3)	51(92.7)
Distance material from the face when reading		
At nose point	0(0.0)	2(1.8)
10 to 25 cm	74(10.9)	39(70.9)
30 to 40 cm	493(72.7)	10(18.2)
Not sure	111(16.4)	4(7.3)
Hours spend at home playing games on the phone		
< 1 hour	0(0.0)	5(9.1)
1 to 2 hours	579(85.5)	2(3.6)
3 to 4 hours	62(9.1)	5(9.1)
> 4 hours	37(5.4)	43(78.2)

Data are presented as frequencies (n) and percentages (%).

4.6 Relationship between Outdoor Activities, Near work Actvities and Myopia

4.6.1 Relationship between outdoor activities and myopia

Logistic regression was conducted to determine the relationship between outdoor activities and myopia. A logistic regression analysis in *table 4.*7 shows that there was no significant influence of outdoor activities on having myopia, though participation in outdoor games was found to decrease the risk of having myopia $\chi^2(8) = 9.75$, $p=0.059$). The model explained 67.2% variance in having myopia (Negelkerke R^2) and was able to identify 11.4% cases accurately. The sensitivity of model was 67.2% and specificity of model was 46.9%.

Table 4.7: Logistic regression for outdoor activities and myopia

Outdoor activities			
	Odds Ratio	95% C.I.	p-value
Participation in sporting	1.268	[0.92-1.73]	0.142
Hours spent on sporting	1.129	[0.74-1.70]	0.566
Participation in daily and weekly sporting	1.066	[0.78-1.45]	0.685
Frequency in participating outdoor activities	0.800	[0.47-1.36]	0.411
Time playing outside the classroom	1.391	[0.97-1.98]	0.70
Hours spent playing outside the classroom	0.866	[0.49-1.53]	0.621
Time outside the house playing with friends	0.886	0.63-1.23]	0.476
Hours spent outside the house playing with friends	1.038	[0.57-1.88]	0.901
Constant	0.354	-1.038	0.489

Data was presented as OR, odds ratio, 95 CI, binary logistic regression was done P < 0.05 was considered as significant

Omnibus $\chi 2(8) = 9.75$, $p<0.05$, R2=.85(cox and Snell),0.114(Nagelkerke)*$p<0.05$

4.6.2 Relationship between near work activities and myopia

Logistic regression was administered to determine the connection between near work activities and myopia. A logistic regression analysis in *table 4.8* shows that there was significant influence of near work activities on myopia (χ^2 (14) = 44.122, p = 0.005. The odds ratio indicated that having extra/revision classes every day or at weekends increased the probability of having myopia by 2.983. In addition, having more hours for extra classes or revision increased probability of myopia by 2.017. On the other hand, reducing the number of hours spent reading newspapers reduced the probability of having myopia by 0.88. The model explained 45.3% variance in having myopia (Negelkerke R^2) and was able to identify 77.6% cases accurately. The sensitivity of model was 81.7% and specificity of model was 72.35%.

Table 4.8: Logistic regression for near work related activities and myopia

Near Related Activities	Odds Ratio	95% C. I	p- values
Attendance of classes every day	0.732	[0.44-1.16]	0.188
Number of classes	0.742	[.39-1.39]	0.355
Extra/revision classes every day	3.983	[1.78-8.89]	**0.001**
Length of extra/revision classes	3.017	[1.39-6.50]	**0.005**
Sit/stand < 3 metres to watch TV at home	1.330	[0.83-2.12]	0.233
Distance from sitting point to TV	0.691	[0.41-1.15]	0.158
Long hours on the computer	0.612	[0.35-1.05]	0.077
Hours spent on computer	0.563	[0.25-1.25]	0.161
Reading magazines every day	1.095	[0.69-1.72]	0.697
Hours spend reading story books/newspapers	0.216	[0.52-0.90]	**0.036**
Bring the books very close to face	0.844	[0.54-1.31]	0.453
Closeness to the face	0.573	[0.26-1.26]	0.167
Time at home playing with on the phone	1.019	[0.65-1.58]	0.934
Hours playing on the phone	0.663	[0.26-1.64]	0.375
Constant	193.737	5.267	0.051

Data was presented as OR, odds ratio, 95 CI, binary logistic regression was done $p < 0.05$ was considered as significant

Omnibus $\chi 2(8) = 9.75$, $p<0.05$, R2=.85(cox and Snell),0.114(Nagelkerke)*$p<0.05$

CHAPTER FIVE

DISCUSSION OF THE RESULTS

5.1 Prevalence of Myopia

The prevalence of myopia in this study was found to be 7.5%. This was higher compared to Bastawrous, *et al.,* (2013a) study done in Nakuru that found the prevalence to be 1.7%. Similarly, a study done by Muma *et al.,* (2009) in Makueni found a similar prevalence of 1.7%, while a study done in Meru found a prevalence of 6.7% (Njeru *et al.,* 2013). The higher prevalence reported in this study can be attributed to the population of the study which consisted majorly of adolescents, while the population of the above studies consisted of primary school going pupils aged between 6 – 10 years old. It is well established that myopia is highly prevalent in adolescents as compared to younger age groups (Rudnicka *et al.,* 2016). The high prevalence in adolescents has been attributed to the eyeball elongation during puberty (Cui *et al.,* 2013). This is because of their involvement in a lot of reading causing eyeball elongation due to peripheral defocus and retinal blur caused by lag of accommodation (Gonzalez *et al.,* 2008).

The higher prevalence reported in this study can also be attributed to the method of data collection employed. In the other studies, (Bastawrous, *et al.,* 2013b;Muma *et al.,* 2009;Njeru *et al.,* 2013), refraction was done by a refractometer on non-cycloplegic students, while a retinoscope was used for refraction in cycloplegic students in this study. This could have led to under estimation of prevalence of myopia in the above studies.

In addition, the higher prevalence reported in this study can be attributed to the global increment in prevalence of myopia experienced globally (Bruce, 2017). It is believed that myopia is on the rise (Rudnicka *et al.,* 2016) and the rapid increment has been associated with outdoor activities and near work activities, though this is not conclusive (French *et al.,* 2013). Furthermore, some researchers believe that there is an interaction between environmental and genetic factors that is responsible for the increment in prevalence (Dirani *et al.,* 2006).

Nyamai *et al.,* (2016) found a prevalence of 15.6% which is higher compared to the prevalence found in this study, although Nyamai's study was done in Nairobi with majority of participants coming from the central business area. Nairobi is an urban area as compared to Lurambi sub- county, which is semi urban. This may have caused the variation in the prevalence since myopia has generally been found to be highly prevalent in urban areas as compared to rural or semi urban areas (Pan *et al.,* 2012).

5.2 Social Demographic Factors and Prevalence of Myopia

5.2.1 Gender and Myopia Prevalence

Out of the 733 students who participated in the study, 45% were females while 55% were males. Myopia was found to be more prevalent in males 29(52.7%) than in females 26(47.3%). The difference in prevalence among males and females was not significant (p = 0.576) since most of the schools where the study was conducted almost had an equal number of females and males. This may be due to the influence of Kenyan government and human right organization's emphasis on girlchild education and equity in the country.

Several studies have found myopia to be more prevalent in females compared to males (Wanyoike M *et al.,* 2007; Pan *et al.,* 2012). This is because females experience early growth and maturity rate as compared to males (Moldowan *et al.,* 2015). Moreover, oestrogen hormones secreted during menstruation has been found to cause fluctuation of vision that can lead to micro fluctuation in accommodation (Gong *et al.,* 2015). This could lead to retinal blur hence there may be stimulation of eyeball elongation leading to development of myopia (Aleman & Schaeffel, 2018). The contrast in the studies can be attributed to difference in sampling frame of this study as compared to the above studies. Cultural difference could have also played a role since there are variations in level of involvement in outdoor activities and near work activities owing to the lifestyle characteristics practice in different ethnics (Paul *et al.,*2013).

This study was consistent with Bastawrous *et al.,* (2013c) which established that there was no statistically significant difference in prevalence among females and males. Kawuma *et al.,* (2009) and Nzuki *et al.,* (2007) found myopia to be more prevalent in females, with males and females at 1.8% and 1.7% respectively. The difference was not statistically significant. There was a difference when compared to this study that found myopia to be more in males than females. The variation can be attributed to age differences of study sample or the definition of myopia in the study.

5.2.2 Age and myopia prevalence

The study participants were majorly between the ages of 15 -18 years; this was 502 out of 733 number of students screened in the study. The study found that myopia was mostly prevalent in the age group of 15-18 years and it increased with age. This could be due to their involvement in a lot of near work-related activities and less outdoor activities. This age group is mostly found in the upper classes of high school

and the national exams pressure exacerbates the tendency to be involved in a lot of near work.

Myopia has been found to increase steadily with increasing age and correlated positively with older age (Huang *et al.,* 2018) as shown in this study. The reason for the steady increase in the prevalence of myopia has been attributed to lag of accommodation that results to axial length elongation as a result to near related activities. It is believed that the prevalence of myopia in preschool is lower as compared to school going children. However, there is no consensus on the exact involvement of near work activities on myopia development and progression. In contrary, Wagner *et al.,* (2019) believed that myopia could be more prevalent in preschool compared to the adolescents or school going children. He believed that preschool children have unstable accommodation or inaccuracy of accommodation that lead to lag of accommodation as a result, there is stimulation of eyeball elongation due to retinal blur.

The findings of this study are different to Naidoo *et al.,* (2013) study that was conducted in Uganda which asserted that myopia is highly prevalent in 11-14-year-olds. The difference in the findings can be attributed to early schooling in Uganda though this is not conclusive.

5.2.3 Residential area and prevalence of myopia

Most of the study population came from the rural area since Kakamega county is mostly rural. Urban setting is in the square radius of 10 kilometres from the town centre. Most secondary schools are also found in the rural area with few schools found in the urban area. This study found that myopia was mostly prevalent in students from the urban area compared to the students from the rural area even

though the most domicile area was rural area. This study is similar with (Ip *et al.*, 2019) study that found high prevalence of myopia in urban areas compared to the rural areas (Rose, *et al.*, 2008). Ip *et al.*, (2008) study found out that the prevalence of childhood myopia was lowest (6.9%) in the outer suburban regions and highest (17.8%) in the inner-city regions. Although comparison of prevalence of myopia in the two settings is difficult due to impact of other confounding factors such as education, schooling and outdoor activity, these factors make it difficult to entirely associate the differences with the urban or rural environment alone.

The reason for the high prevalence of myopia in urban settings has been attributed to the rise in technology and the increased usage of phones, computers and televisions especially among children and youths. This plus less outdoor activities have been found to have some influence with onset development and progression of myopia (Hsu *et al.*, 2016).

Children in urban settings in this era are less involved in outdoor activities unlike children in 80's and early 90's. This could be due to unavailability of playing grounds because areas set aside for such have high rise buildings erected on them. As a result, children have opted for indoor activities and games instead of outdoor activities (You *et al.*, 2012).

5.2.4 Class of respondent and myopia prevalence

The prevalence of myopia was found to be increasing with the class of the respondents. It was established that myopia was highly prevalent among form four students and least prevalent in lower forms. This can be attributed to the educational pressure in upper classes, that is forms four and three (Rose, *et al.*, 2008). The

pressure is because of the Kenya National Examination (KNEC) that is done at the end of the fourth form.

Educational pressure has been shown to be having a significant relationship with myopia (Bez *et al.,* 2019), because in order to get good grades in the final national examination, one has to study more. This involves a lot of near related activities that have been confirmed to have influence on myopia. Although educational pressure is believed to be a surrogate of near work (Junghans & Crewther, 2003), this could have explained the reason why prevalence of myopia in form one was much closer to that of form four in this study.

5.3 Level of involvement in Outdoor Activities and Myopia

Outdoor activities were evaluated as having participated in any sporting activity, hours spent participating in outdoor activities, time spent playing outside the classroom and in the field, as well as time spent playing outside the house or at home playing with friends and neighbours.

This study found that students who took part on sporting and outdoor activities spent more than 3 hours outdoors every day, spent plenty of time playing outside the classroom, spent more than 2 hours playing outside classroom as well as spent more time outside the house, the proportion of those who were non-myopic was higher than those with myopia. The mechanism behind the relationship between outdoor activities and myopia is not well understood. There is a belief that greater light intensity outdoors causes pupillary constriction resulting in an increase in the field of depth hence reducing the retinal blur (Dharani *et al.,* 2018) This could be the explanation behind higher proportion of non-myopia in students who were involved in a lot of outdoor activities. Hua *et al.,* (2015) however believed that it is not the

light intensity but the spectral composition of light that associates outdoor activities with myopia.

This is consistent with Pan, Ramamurthy, & Saw,(2012) who found that children who spent significant amount of more hours per week in outdoor/sports activities were likely to be non-myopic as compared to those who spent less time participating in outdoor activities. This is also similar to French *et al.,* (2013) study which asserted that non-myopic students spent more time outdoors compared to myopic students. In addition, interventional studies have shown that outdoor activities during class recess or an additional class of structured outdoors activities after school led to a significant effect on myopia onset and myopic shift (Rose *et al.,* 2008; Wu., *et al.,* 2012). This is because axial length has been significantly associated with less time spent outdoors and more time spent indoors studying (Wu *et al.,* 2018). In contrary, Guo *et al.,* (2016) believed that there is no statistical significance in the difference in hours spent engaging in outdoor activities among myopic and non-myopic students, although the study design was longitudinal and there was difference on how they quantified outdoor activities. This could have led to the disagreements between this study's results and Guo *et al.,* (2016) study findings.

5.4 Level of involvement in Near Work and Myopia

Near work was defined as activities done at fleeting working distance including reading, studying (homework, writing), computer use, playing video games or watching television. The study found that students who took more that 4 classes every day, took extra revision classes daily, students who sat or stood 1 or less metres from TV, watched TV for more than 2 hours, spend longer hours playing games on the phone, spent plenty of time reading story books as well as brought

book very close to face, the proportion of those who were myopic was higher than those who were non-myopic. This is consistent with (Guo *et al.,* 2016) which found the proportion of myopic students who; studied more than 2 hours per day, read for pleasure more than 2 hours per day, read closer than 25 cm and watched television closer than 3m,to be greater than that of non-myopic. This explains why myopia might be influenced by near work activities.

It is believed that students who perform significant amount of near work are likely to be myopic as compared to those who do not engage in significant amount of near work (Huang, *et al.,* 2015). Although some studies report that the type of near work may be important than the total duration of time performing near work, others believe that continuous reading for more than 40 minutes without a break maybe worse more than the total duration of time performing near work activities (Bez *et al.,* 2019; Lin *et al.,* 2014; You *et al.,* 2016; Zhuo *et al.,* 2018).

The study also found that the proportion of non-myopic students who spend more hours on computers every day was greater than that of myopic students. This is contrary to (Ip *et al.,* 2008) study that demonstrated that myopes spent more time on computers compared to non-myopes. This also differed with Saxena *et al.,* (2015) that found myopia to be higher in those involved in near work activities such as exposure to computers, for more than 5 hours a week. However, questionnaires were issued to the students' parents in both studies as opposed to the students. Students in a study were found to underestimate the amount of near work compared to the parents (Zhuo *et al.,* 2018) hence this can be the reason for differences in the finding of this study and their study. Another reason could be the recall bias, relying on the students' feedback might have led to the differences in findings of the studies.

It has been established that myopes have thick ciliary body compared to the non-myopes. This causes inaccuracy in accommodation resulting in accommodative lag hence leading to myopia (Wagner *et al.,* 2019). This makes the cause of myopia to be anatomical rather than optical influence. Accommodative lag and micro fluctuation are as a result of tension in the crystalline lens, the tension creates resistance in accommodation thus increasing the effort needed to accommodate, leading to accommodative lag (Huryn *et al.,* 2019). This is contrary to the debate that near work activities cause myopia.

5.5 Relationship between Outdoor Activities, Near Work activities and Myopia

5.5.1 Relationship between outdoor activities and myopia

There was no significant relationship between outdoor activities and having myopia. However, it was established that participating in sporting activities reduces the chance of having myopia. The lack of relationship between outdoor activities and myopia could be attributed to recall bias and the qualitative measure of the outdoor activities. The difference in the study design could also have contributed to the lack of relationship between outdoor activities and myopia. A study done to investigate the response of students and parents on the near work and outdoor activities found that there was underestimation of the response of students and parents when compared to the real measure of outdoor activities and myopia (Zhuo *et al.*, 2018). This could have explained the influence of the recall bias in this study. Other studies that employed the use of questionnaires, as used in this study, found outdoor activities to be associated with myopia.

Findings of the present study differs from most of the previous studies which established that time spent in outdoor activities affects the probability of being myopic. For instance, (Ip, *et al.,* 2008) found out that spending more time outdoor

reduces chances of being myopic while (Guo *et al.,* 2017) established that less time in sports activity contributes a smaller percentage on juvenile myopia. This difference could be attributed to low prevalence of myopia and the small sample size in this study compared to the above studies. However, (Kuo, *et al.,* 2012) noted that outdoor activities are believed to be clinically significant but not statistically significant. This explained why participating in sporting activities to reduce the chances of having myopia by twice in this study. Findings have shown that when children spend more time playing outside, they reduce probability of being myopic.

Participation in outdoor activities have proved to be clinically significant in delaying development of myopia (French, *et al.,* 2013). Sunlight exposure activates D2-dopamine receptors found in the horizontal and amacrine cells in the retina to produce dopamine, a neurotransmitter responsible for hindering growth of the eyeball by inhibiting cholinergic receptors. This thus delays myopia development or prevents myopia development (Norton & Siegwart, 2013). This research was however not conclusive on whether dopamine is released by the retinal cells when exposed to sunlight or not because measuring dopamine in the retina proved to be very complicated. Muttie *et al.,* (2007) tried to measure the amount of vitamin D on myopic patients, results showed they had lower vitamin D though this still does not explain the influence of outdoor activity on myopia (Jones *et al.,* 2007). Whether outdoor activities have relationship with myopia is still a puzzle to be solved because it is unclear how outdoor activities have influence on myopia.

5.5.2 Relationship between near work and myopia

Near work-related activities had a significant effect on the likelihood of having myopia. This is in line with the findings of Cordain *et al., (*2018) and Lin *et al.,* (2017). This proves the suppositions of use - abuse theory on environmental

influence. Lu *et al.,* (2009) disputes the association between near related activities and having myopia stating that there was no association between near related activities and having or development of myopia.

Odds ratio indicated that having extra/revision classes every day or during weekends increased the probability of having myopia. On the other hand, reducing the number of hours spent reading newspapers reduces probability of having myopia. This can be explained by the fact that having more revision classes increased near work related activities, and thus increase in visual demand at near results to the development of myopia or onset of myopia. A decrease in working distance, especially less than 50cm, increases accommodative demand which increases the probability of myopia. When undertaking extra revision classes, students have to read for longer and in most cases less than 30 cm. Working distance has been attributed to myopia (Guo *et al.,* 2016), though its association with myopia is not well understood since myopes generally have to use short working distance to read. The affiliation may well be translated either as proof that close work causes myopia or that myopic people incline towards a closer perusing distance owing to the shorter focal length of their eyes' optical framework when uncorrected with spectacles.

This increases the probability of being myopic compared to those who do not have more remedial classes. An increase in reading time increases time of sustain lag of accommodation which results to increased peripheral hyperopic defocus and central hyperopic defocus. Due to an increase in peripheral and central hyperopic defocus, there will be axial length elongation (Wagner, *et al.,* 2019). The elongation will result in increased probability of the development of myopia. This is attributed to the fact that the body has its limitations especially when the eye is using its muscles. In particular, when eyes and the surrounding tissues are used for close work for a long

time, the whole system of muscles and tissues are forced to adapt to the challenge. In this regard, extra classes increase near work which influence the eyes to become more and more adapted over time (Mihelcic, 2013). On the other hand, a reduction in time spent reading newspapers at close range leads to a reduction in probability of being myopic.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

The prevalence of myopia in this study was found to be 7.5% and was higher in males as compared to the females. It was found to be more prevalent in those aged between 15 to 18-year old. Most of the affected were from urban areas and the prevalence was higher in those in upper classes (form 4) compared to those in lower classes (form 1).

Most of the non-myopic students reported to taking part in sporting and outdoor activities most days of the week. Participants involved in sporting activities spent one to two hours per day on outdoor activities. Most of those who took part in sporting activities did not spend plenty of time playing outside the classroom and in the field at school every day.

Most of the myopic students in the study admitted to having extra revision classes during the week that added up to 6 classes. A majority of the myopic students spent plenty of time reading storybooks, magazines and newspapers. In the same regard, most of the students who were myopic agreed that when reading, they held books closer to their eyes to a proximity of 10 to 25cm. The findings also showed that most of the myopic students spend their time playing on their phones.

The findings showed that there was no significant association between outdoor activities and having myopia, although participating in outdoor activities reduced the odds of having myopia. This explains why myopia is clinically significant but not statistically significant. However, this finding differs from most of the previous

studies that have established that there was a relationship between outdoor activities and myopia.

The study found that there was a significant relationship between near related activities and myopia. In particular, the odds ratio indicated that having extra/revision classes every day or at weekends increased the probability of having myopia. On the other hand, reducing the number of hours spent reading newspapers reduces probability of having myopia. This can be attributed to the fact that sustain near work activities results to sustain lag of accommodation and results to central and peripheral hyperopic defocus that results to myopia development and progression. The reading distance of the students had a direct link to having myopia. Reduction in reading distance, especially less than 50cm, increased visual demand and hyperopic defocus thus increasing the probability of myopia. In particular, when eyes and the surrounding tissues are used for close work, the whole system of muscles and tissues are forced to adapt to the challenge. In this regard, extra classes increase near work which influence the eyes to become more adapted over time. On the other hand, a reduction in time spent reading newspapers at close range leads to a reduction in probability of being myopic.

6.2 Recommendations

There should be emphasis on the need for regular screening program in secondary schools to control the prevalence of myopia and prevent myopia from being a world pandemic. This should be especially done on students aged between 15-18 years since the prevalence of myopia was higher at this age. Students should be encouraged to take part in more outdoor activities to reduce the chances of developing myopia. myopia. Extra revision classes should be discouraged since myopia was found to increase with extra revision classes, while a longer reading distance (more than 25cm) should be encouraged because shorter reading distance was found to increase the chances of being myopic. In addition, even though children should be encouraged to study, they should also be able to spend time outdoors instead of playing computer games. The government and other stakeholders should have initiatives to educate the public on the risk factors (outdoor activities and near work activities) of myopia. This is because some of the effects such as spending more time reading especially at close range increases the chances of being myopic. This helps parents encourage students to avoid habits that increases likelihood of being myopic. The findings of this research were shared with the teachers and the ministry of education.

There should be further research to determine the moderating and mediating the correlation between near work and having myopia. For instance, the effect of nutrition. There should be further research to determine the factors contributing to variations in rural and urban settings which contribute to myopia.

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APPENDICES

Appendix I: Sample Permission Letter for Free Community Eye Screening

LETTER OF PERMISSION TO CARRY OUT STUDY

Department of optometry and Vision science,
Masinde Muliro University of science and Technology,
Kakamega,

(Institution or authority Desired)

Dear Sir/Madam,

APPLICATION FOR PERMISSION TO CARRY OUT A RESEARCH STUDY/FREE EYE SCREENING IN YOUR INSTITUTION/COMMUNITY

I am a Master student at the Masinde Muliro University of science and Technology currently conducting a study on the **influence of outdoor and near work activities on myopia amongst secondary school students in Lurambi Sub-County.**

I write to seek your permission to conduct a free school eye examination in your school(s), as a component of the study entails eye examinations and surveys of children who are aged 13-19 years. The examination and questionnaires to be distributed is to enable the researcher to obtain information for academic research purposes only. The study is aimed at investigating influence of outdoor and near work activities on myopia amongst school-going adolescents in Lurambi Sub-County.

The study is further aimed at promoting child eye care services utilization in the County. Information received from the participating school children will be treated with utmost confidentiality. Kindly find a copy of the full study proposal, accompanying this letter of request, for your understanding and knowledge of the study aims, objectives and procedures to be followed.

Your assistance in this regard as well as helping in mobilizing your schools and students towards participating in the study exercise would be of immense help to the success of the study.

Thanking you in anticipation of your approval of this request.

Yours Faithfully,

Alfred Ragot
Department of Optometry and
Vision Sciences,
Masinde Muliro University of Science
And Technology
Researcher.

Appendix II: Sample Consent Form for Identified Inclusions

INFORMATION NOTE AND LETTER OF CONSENT

TITILE; INFLUENCE OF OUTDOOR AND NEAR WORK ACTIVITIES ON MYOPIA AMONGST SECONDARY SCHOOL STUDENTS IN LURAMBI SUB-COUNTY

RESEARCHER; ALFRED RAGOT

INSTITUTION; MASINDE MULIRO UNIVERSITY OF SCIENCE ANDTECHNOLOGY

SUPERVISORS

DR. MUSTAFA BARAZA

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY

PROF PETER CLARKE-FARR

UNIVERSITY OF KWAZULU-NATAL

Introduction:

I would like to tell you about a study being conducted by the above listed researchers. The purpose of this consent form is to give you the information you will need to help you decide whether or not your child should participate in the study. Feel free to ask any questions about the purpose of the research, what happens if your child participates in the study, the possible risks and benefits, the rights of your child as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions to your satisfaction, you may decide if you want your child to be in the study or not. This process is called 'informed consent'. Once you understand and agree for your child to be in the study, I will request you to sign your name on this form. You should understand the general principles which apply to all participants in a medical research: i) Your child decision to participate is entirely voluntary ii) Your child may withdraw from the study at any time without necessarily giving a reason for his/her withdrawal iii) Refusal to participate in the research will not affect the services your child is entitled to in this health facility or other facilities.

May I continue? YES / NO

For children below 18 years of age we give information about the study to parents or guardians. We will go over this information with you and you need to give permission in order for your child to participate in this study. We will give you a copy of this form for your records.

The researcher above will issue questionnaire to your child with the intention to get information on their outdoor activities and near related task, the need is motivated by the need to address avoidable childhood vision impairment due to myopia which is on the rise and may be contributed with environmental factors (outdoor activities and near related task). The study is set to investigate the influence of outdoor activities and near related task on myopia comparing those in rural and those in urban. This ultimately with the view to make recommendations based on the expected findings from this research, that will promote effective planning which will alleviate the burdens of vision impairment due myopia in the average Kenyan child.

The activities included in this study will involve eye examinations of your child and their responses, derived from their perspective and/or judgement, to series of questionnaires. The exercise (the questionings – written, and eye examinations) are purely for academic research purpose. Any information – views and personal details, they will give in the course of this study, will be treated with utmost confidentiality. You or your child has the right at any point of the study, to not respond to any question they are not sure or comfortable with. You or they also have the right to withdraw them from the examination process or research protocol at any point you choose not to continue in the study.

The study will involve rigorous eye examination and varying level of questionings. Some of the drugs to be used in the course of the eye examination may cause slight irritation but no serious harm to your child. Most of all, the activities will 2HRS to complete. However, plans will be made with the school authority for make-up classes for the days/hours missed in class work. A light lunch, snack and juice will be provided to your child. Needed optical correction aids and medication will also be provided to your child, should they require such, at no cost to you.

Please note that your signing this note means your full understanding and acceptance of your child to participate in this study. Also note that, your unwillingness to consent to your child's involvement in this study will be well respected and will in no way deny your child of any privilege(s) that may likely come out of this study.

Should you require further clarification on details of the above with regards to your child's involvement in this study, please contact the principal investigator (PI) through your child's school principal or contact the PI directly on **0716584698.**

Or feel free to contact:

Dr. Gordon Nguka
Institutional Research Ethics committee (IREC, MMUST)
Directorate of Research, extension and Linkages
Masinde Muliro University of Science and Technology
P. O. Box 190-50100, Kakamega
Tel: 0771698900
Kenya

Thank you in anticipation of your kind consent for your child to participate in this study.

Yours Faithfully,

Participant's Legal Guardian's signature

Appendix III: Structured Questionnaire for the Study

NO.	QUESTION	RESPONSES	SEVERITY
	Section A: SOCIAL DEMOGRAPHIC CHARACTERISTICS		
1	Which class are you in?	01 Form one 02 Form Two 03 Form Three 04 Form Four	
2	Your Parents address:		
3	Your Parents phone number:		
4	Your Place of Residence:		
5	Your Gender		
6	Age		
	Section B: NEAR WORK		
7	I often attend plenty of classes everyday	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	How many? 01 1 to 3 classes 02 4 to 6 classes 03 More than 6 classes
8	I often have extra/revision classes every day or at weekends	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	For how long? 01 less than 1 hour 02 1 to 2 hours 03 3 to 4 hours 04 more than 4 hours
9	I often sit/stand less than 3 meters to watch the TV at home	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	What distance: 01 1 meter or less 02 2 to 3 meters 03 more 3 meters 04 not sure
10	I spend plenty of time/ long hours on the computer	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	For how long? 01 less than 1 hour 02 1 to 2 hours 03 3 to 4 hours 04 more than 4 hours

11	I spend plenty of time reading story books/magazines/newspapers every day.	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	For how long? 01 less than 1 hour 02 1 to 2 hours 03 3 to 4 hours 04 more than 4 hours
12	While reading or writing, I often bring the books very close to my face	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	How close? 01 At my nose point 02 10 to 25cm 03 30 to 40 cm 04 not sure
13	I spend plenty of time at home playing games on the phone	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	For how long? 01 less than 1 hour 02 1 to 2 hours 03 3 to 4 hours 04 more than 4 hours
14	One or more other members of my family is/are also using prescribed glasses to view distance object.	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	01 Father 02 Mother 03 At least one grandparent 04 at least one sibling
	Section C: OUTDOOR ACTIVITES		
15	I often like to participate in sporting and other outdoor games every day or most days in a week	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	For how long? 01 less than 1 hour 02 1 to 2 hours 03 3 to 4 hours 04 more than 4 hours
16	I often spend plenty of time participating daily and weekly on sporting and other outdoor games and activities e.g. hiking, tours, sight-seeing etc.	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	How frequent? 01 More than once a day 02 Once in a day 03 More than once a week 04Every day

17	At school every day, I spend plenty of time playing outside the classroom and in the field	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	For how long? 01 less than 1 hour 02 1 to 2 hours 03 3 to 4 hours 04 more than 4 hours
18	At home and during weekends and holidays; I spend plenty of time outside the house playing with my friends and neighbors	01 strongly agree 02 agree 03 no idea 04 do not agree 05 Strongly disagree	For how long? 01 less than 1 hour 02 1 to 2 hours 03 3 to 4 hours 04 more than 4 hours

Appendix IV; Schools in Lurambi Sub County were the study population was drawn

Rural school in Lurambi Sub-County	Urban school in Lurambi Sub-County
1. Emetetie secondary school	Kakamega township secondary school
2. Indamgalasia secondary school	St Patrick Ikoyero secondary school
3. Esokone secondary school	Kakamega Muslim secondary school
4. Mwangaza secondary school	Shieywe secondary school
5. Eshibeye secondary school	Mwiyala secondary school
6. Ebwambwa secondary school	Rostaman secondary school
7. Eshiru secondary school	Shikoti secondary school
8. Kilimo secondary school	Kakamega High school
9. Ibinzo girls' secondary school	Matende girls secondary
10. Shikoti girls' secondary school	Bishop Sulemeti girls' secondary school
11. Matioli secondary school	Shisango girls' secondary school

Appendix V: Approval letter from Directorate of postgraduate Studies

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

Tel: 056-30870
Fax: 056-30153
E-mail: directordps@mmust.ac.ke
Website: www.mmust.ac.ke

P.O Box 190
Kakamega – 50100
Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

22nd August, 2019

Alfred Ragot,
HOV/G/55817/2016,
P.O. Box 190-50100,
KAKAMEGA.

Dear Mr. Ragot,

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your masters proposal entitled: ***"Influence of Outdoor and Near Work Activities on Myopia amongst Secondary School Going Adolescents in Lurambi Sub-County"*** and appointed the following as supervisors:

1. Prof. Peter Clerke- Farr - Universiy of Kwazulu - Natal
2. Dr. Mustafa Baraza - SPHBST, MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Public Health, Biomedical Sciences and Technology Graduate Studies Committee and Chairman, Optometry and Vision Sciences Department. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of two years from the date of registration to complete your master's thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours Sincerely,

Prof. John Obiri
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

Appendix VI: Approval letter from Institutional Ethics Review Committee

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY
Tel: 056-31375
Fax: 056-30153
E-mail: ierc@mmust.ac.ke
Website: www.mmust.ac.ke
P. O. Box 190-50100
Kakamega, Kenya

Institutional Ethics Review Committee (IERC)

Ref: MMU/COR: 403012 vol2 (48) **Date:** 9th September, 2019

Alfred Ragot
Masinde Muliro University of Science and Technology
P.O. Box 190-50100
KAKAMEGA

Dear Mr. Ragot

RE: Influence of outdoor and near work activities on myopia amongst secondary school going adolescents in Lurambi sub-county - MMUST/IERC/077 /19

Thank you for submitting your proposal entitled as above for initial review. This is to inform you that the committee conducted the initial review and approved (with no further revisions) the above Referenced application for one year.

This approval is valid from **9th September, 2019 through to 9th September, 2020**. Please note that authorization to conduct this study will automatically expire on **9th September, 2020**. If you plan to continue with data collection or analysis beyond this date please submit an application for continuing approval to the MMUST IERC by **9th August, 2020.**

Approval for continuation of the study will be subject to submission and review of an annual report that must reach the MMUST IERC secretariat by **9th August, 2020**. You are required to submit any amendments to this protocol and any other information pertinent to human participation in this study to MMUST IERC prior to implementation.

Please note that any unanticipated problems or adverse effects/events resulting from the conduct of this study must be reported to **MMUST IERC**. Also note that you are required to seek for research permit from **NACOSTI** prior to the initiation of the study.

Yours faithfully,

Dr. Gordon Nguka (PhD)
Chairman, Institutional Ethics Review Committee

Copy to:
- The Secretary, National Bio-Ethics Committee
- Vice Chancellor
- DVC (PR&I)
- DVC (A & F)

Approval VII: NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **884018**

Date of Issue: **30/September/2019**

RESEARCH LICENSE

This is to Certify that Mr.. ALFRED RAGOT of Maseno Multro University of Science and Technology, has been licensed to conduct research in Kakamega on the topic: INFLUENCE OF OUTDOOR AND NEAR WORK ACTIVITIES ON MYOPIA AMONGST SECONDARY SCHOOL GOING ADOLESCENTS IN LURAMBI SUB-COUNTY for the period ending : 30/September/2020.

License No: **NACOSTI/P/19/1636**

884018

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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1. The License is valid for the proposed research, location and specified period
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3. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research
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8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice

Appendix VIII: Map of Lurambi Sub-County