PREVALENCE OF AMETROPIA AMONG PUBLIC HIGH SCHOOL STUDENTS IN CUSCO PROVINCE, PERU

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DECLARATION

This dissertation is my original work and has not been presented for a degree in any other University.

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DEDICATION

Dedicated to my loving wife Ruth Mery and my wonderful son Rafael for their patience and their encouragement.

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ACRONYMS AND ABBREVIATIONS

APAFA	Children parent's association
BCVA	Best corrected visual acuity
CMP	Medical Peruvian College
D	Diopter
DC	Diopter cylinder
DS	Diopter sphere
DRE	Regional Direction of Education
LASEK	Laser Subepithelial Keratomileusis
LASIK	Laser in Situ Keratomileusis
LE	Left eye
KNH	Kenyatta National Hospital
PRK	Photorefractive Keratectomy
RE	Right eye
UNICEF	United Nations Children Education Fund
UGEL	Local Educational Management Unit of Cusco Peru
UON	University of Nairobi
VA	Visual Acuity
WHO	World Health Organization

ABSTRACT

BACKGROUND: Blindness at any age of life is a major health concern, therefore if it occurs in early age of life, lifestyle is significantly affected; there is hampered performance at school, reduced employability and productivity. Uncorrected refractive error is one of main causes of visual impairment in children. Correcting refractive errors in children is one of the priorities of the World Health Organization through Vision 2020. No study has been done in Cusco Peru on prevalence or refractive errors in high school students.

OBJECTIVE: To assess the prevalence type and uncorrected refractive error in urban public high school students in Cusco province, Peru.

METHODOLOGY: A cross-sectional study was conducted between September to December 2013, with randomized selection of schools designed to assess the prevalence of refractive error in public high school students in Cusco province, Peru. Ocular examination involved measurements of visual acuity using LogMAR chart at 3 meters to all the students present during the survey period from the selected schools. Those with visual acuity less than 6/12 (0.30) in at least one eye non cyclopegic refraction and subjective refraction was done on all identified cases after ocular motility, anterior segment and fundus examination. Data was analyzed using the SPSS version 17 statistical software.

RESULTS: The study recruited 1537 school students between 11 to 19 years of age, male (48.9%) and female (51.1%). The prevalence was found to be 18.2%. The common type of refractive error was astigmatism (14.6%), followed myopia (3.4%) and hypermetropia (0.1%). Astigmatism was more common in males (87.1%) than females (76.4%) while Myopia was more in females (22.5%) than males (12.9%). The proportion of uncorrected refractive error was 12.4%.

CONCLUSION: The prevalence of refractive error was high enough to justify a regular school eye screening program and the common type of refractive error was astigmatism. Males were at higher risk to be affected by astigmatism and females by myopia. Uncorrected refractive error was significantly high.

1.0 INTRODUCTION

Estimation of global visual impairment has shown that 314 million people are visually impaired. Of these, 153 million people are estimated to be visually impaired from uncorrected refractive errors. Among the causes of blindness, refractive error ranks second to cataracts as a cause of blindness. Uncorrected refractive errors can hamper performance at school, reduce employability, productivity and generally impair quality of life. Yet the correction of refractive errors with appropriate spectacles is among the most cost-effective interventions in eye healthcare.[1]

It is estimated 19 million children below 15 years are visually impaired. Of these, 12 million children are visually impaired due to refractive errors, a condition that could be easily diagnosed and corrected. 1.4 million are irreversibly blind.[2]

Peru in South American is home to over 29 million people, children aged between 0 – 14years are over 8,4 million.[3] Peru has three different regions Coast, Sierra and Forest. Cusco is situated at Sierra Region. No studies on prevalence of refractive error in high school students or children aged between 12 to 16 years have been done in Cusco. The National Ocular Health programme does not routinely carry out screening for refractive error in school aged children.

2.0 LITERATURE REVIEW

2.1.0 OVERVIEW

Emmetropia is the refractive state in which parallel rays of light from a distant object are brought focus on the retina in the nonaccommodating eye. The far point of the emmetropic eye is at infinity, and infinite is conjugate with the retina.[4]

During normal growth and development of the eye, there are dramatic anatomical and physiological changes throughout infancy and early childhood. The axial length of eyes of a newborn is 15-17 mm, in the first 6 months of life this increases by approximately 4 mm thereafter increases by 1 mm in second phase (age 2-5 years) and 1mm in third phase (age 5-13 years) reaching 23-24 mm at adult age. The cornea is approximately 52 Diopters (D) at birth and over the first 6 months it flattens to 46 reaching their adult power of 42-44 D by age 12. The corneal diameter is 9.5 – 10.5 mm at birth, increasing to 12 mm in adulthood. Also the lens power decreases dramatically in the first years of life. The central corneal thickness is 0.96 mm at birth and 0.52 mm at 6 months.[5]

Generally eyes are hyperopic at birth. This hyperopia increases at age 7, followed by a myopic shift toward Plano until the eye reaches its adult dimensions, usually by about 16 years of age.

All these physiological changes during the childhood produce change in refraction with higher risk of eventual progression to myopia, hyperopia and astigmatism which is common and often progressive.[5]

In experimental infant rhesus monkeys between 1 to 4 months age, astigmatism lenses imposed in emmetropization of eyes, showed an infant eye produces compensatory changes in axial growth that eliminate the imposed refractive error.[6]

2.2.0 AMETROPIA

Ametropia refers to the absence of Emmetropia, it’s a disorder but is not a disease per se; Ametropia arises when light rays converge in front or behind the retina, as a consequence of this, images seen are blurred, which is sometimes so severe that it creates functional blindness for affected individuals. Ametropia includes myopia, hypermetropia and astigmatism.[7]

Ametropia can be classified by presumptive etiology as axial or refractive. In axial Ametropia the eyeball is long or short, myopia or hyperopia respectively. In Refractive Ametropia the refractive power of the cornea or lens is abnormal, being excessive in myopia or deficient in hyperopia.[4]

2.2.1 MYOPIA

Known as shortsightedness, is a type of refractive error in which parallel rays of light coming from infinity are focused in front of the retina when accommodation is at rest. Axial myopia is when the anteroposterior length of the eyeball is increased in size. Curvatural myopia occurs due to increased curvature of cornea or lens or both whereas positional myopia is produced by anterior displacement of the lens in the eye. Index myopia results from increase in the refractive index of lens associated with nuclear sclerosis. Myopia due to excessive accommodation occurs in patients with spasm of accommodation.[7]

From birth to 6years of age, the axial length of the eye grows by approximately 5 mm, and one might expect from this a high prevalence in myopia in infants; however most children actually are emmetropic, with only a 2% incidence of myopia at 6 years, this phenomenon is due to an undetermined mechanism called emmetropization during the first 6 years of life. Juvenile onset myopia is between 7 and 16 years of age, and is due primarily to growth in axial length. In the United States, the mean rate of childhood myopia progression is reported at about 0.5 D per year. In approximately 75% of teenagers, refractive error is stabilizes at about 15 to 16 years of age.[4]

Myopic eyes are known to have longer axial lengths and vitreous chamber depths compared to emmetropic eyes. Eyes with longer axial lengths tend to have higher cup-disc ratios, increased optic nerve fiber layer defects and possibly greater deformity of the lamina cribrosa, leading to high susceptibility to glaucomatous optic disc changes.[8]

One recent review of familial studies indicates a definite genetic basis for high myopia, and a strong genetic basis for low myopia.[9] Other etiologic factors for the development myopia include environmental factors and near work which appears to be a major risk factor.[10]

Myopia can be classified into two groups. Low to moderate degree of myopia, referred to as simple myopia -0.5 D to -6.0 D. High or pathological myopia, greater than -6.0 D. Simple

myopia can be corrected with spectacles or contact lenses whereas high myopia may be complicated by potentially blinding conditions such as vitreous and macular degeneration and retinal detachment.[11]

2.2.2 HYPERMETROPIA

Also called Hyperopia or long sightedness is the refractive state of the eye where in parallel rays of light coming from infinity are focused behind the retina with nonaccommodating eye, therefore receives a blurred image.[7] The average in diopters power of babies at birth is 3.0 D of hyperopia, and this increase over the next months, but then declines to an average of 1.0 D by age 1. In Children between 3 to 14 years the average corneal power decreases by 0.1 – 0.2 D, and lens power decreases by approximately 1.8 D.[4]

Etiologically hyperopia is classified: Axial hyperopia is the commonest form, 1mm shortening of the eyeball results in 3D of hypermetropia. Curvatural hyperopia result by flattening of curvature of the cornea or lens or both, therefore diminish the refractive power of the eye, 1mm increase in radius of curvature results in 6D of hyperopia. Index hyperopia is due to change in refractive index of the lens in old age. Positional hyperopia results from posteriorly placed crystalline lens. Aphakia results in high hyperopia[7].

Clinically hyperopia may be divided in three categories: Simple hyperopia, due to normal biological variation, can be axial or refractive. Pathological hyperopia caused by abnormal ocular anatomy due to maldevelopment, ocular disease, or trauma. Functional hyperopia results from paralysis of accommodation.[12]

Hyperopia may also be categorized by degree of refractive error: Low hyperopia consists of an error of +2.00 D or less. Moderate hyperopia includes a range of error from +2.25 to +5.00 D. High Hyperopia consists of an error over +5.00 D.[13]

Hyperopia in relation to accommodation: Facultative hyperopia is that which can be overcome by accommodation.[13] Absolute hyperopia is that which cannot be compensated with accommodation.[14]

Hyperopia can also be based upon the outcome of noncycloplegic and cyclopegic refractions: Manifest hyperopia, determined by noncycloplegic refraction, may be either facultative or absolute. Latent hyperopia, detected only by cyclopegia, can be overcome by accommodation.

2.2.3 ASTIGMATISM

Astigmatism is a type of refractive error where the refractive power of the eye varies in different meridians, therefore the rays of light entering the eye cannot converge to a point focus, but the image is formed as a Sturm`s Conoid[15]

Astigmatism is classified into regular and irregular.

The regular astigmatism is when the principal meridians are at 90^0 to each other.[15]

Etiologically regular astigmatism can be classified: Corneal, lenticular or retinal astigmatism, but the most common presentation is the corneal astigmatism.[7]

Regular astigmatism according to the axis and angle between the two principal meridians can be classified into: With the Rule, correction requires the concave cylinder at 180 +/- 20^0 or convex cylindrical lens at 90 +/- 20^0. Against the rule, corrections require convex cylindrical lens at 180+/- 20^0 or concave cylindrical lens at 90 +/- 20^0. Oblique astigmatism has the principal meridians at or near 45^0 and 135^0.[4]

Regular astigmatism also can be classified according position of two focal lines in relation to the retina: Simple astigmatism, one ray focused the retina and another focused in front of retina (simple myopic astigmatism) or behind the retina (simple hyperopic astigmatism). Compound astigmatism, both meridians focused in front of retina (compound myopic astigmatism) and both meridians focused behind the retina (compound hyperopic astigmatism). Mixed astigmatism, one meridian focused in front of retina and another meridian behind the retina.[16]

In irregular astigmatism, the principal meridians are not at 90^0 to each other, and cannot be correct by spectacles.[15]

2.3.0 PREVALENCE OF AMETROPIA

According to WHO, the prevalence of ametropia or refractive error in the world is approximately 153 million people. Of these approximately 12.8 million are in the age group 5–15 years. The highest prevalence has been reported in urban areas.[1]

Different studies on refractive error have been done in the world among different age groups. Studies in children aged up to 15 years shown a prevalence of 12.8% in Pakistan[17] ,Southern Ethiopia[18]11.8% ,China[19] 12.8%, Chile [20] 9.8%, Baltimore USA[21] 8.2%, Tanzania[22] 6.1%.

The prevalence of refractive errors in school children (12-17 Years) of Ahmedabad City - Indian with visual acuity less than 6/9 was 25.32%. The distribution was as follows: Myopia 63.5%, Hypermetropia 11.2% and astigmatism 20.4%.[23] Another study prevalence of refractive error in children age 11 to 15 years in Joypurhat district – Bangladesh with visual acuity worse than 6/12 showed 3.0% prevalence with myopia 2.69% and hyperopia 0.3%.[24]

Prevalence of refractive error in school-aged children in many studies is incomparable because they use different definitions, different measurement methods, different reporting systems and associations using different groupings of ages. Some compared age, gender or ethnicity; others associated it with socioeconomic status, geographic areas (urban, rural) and categorized them differently.

The distribution of myopia as shown in table 1 by ethnicity in different countries in children within 5-15 years was found to be of higher prevalence in China 21.6% compared to Chile 5.8%, India 5.0%, United States (USA) 5.0% and Puerto Rico 0.3%.[25]

Table 1: Prevalence of myopia and hyperopia in children in various regions.

Country	Reference	Year	Age range years	Myopia	Prevalence of Myopia (%)	Hyperopia	Prevalence of Hyperopia (%)
Chile	Maul	2000	5-15	≤-0.50	5.8	≥2.00	14.5
India	Dandona	1999	<16	<-0.50	5.0	>0.50	5.84
Nepal	Pokharel	2000	5-15	≤-0.50	0.3	≥2.00	1.1
China	Zhao	2000	5-15	≤-0.50	21.6	≥2.00	2.7
USA	Zadnik	1999	5-13	≤-0.75	5.0	n/a	n/a
Puerto Rico	Gordon	1990	5-15	≤-0.50	0.3	≥0.50	47.1
Madagascar	Auzemery	1995	8-14	≤6/9	0.9	≤6/9	1.1
Oman	Lithander	1999	6-12	≤-1.00	0.6 - 5.2	n/a	n/a
UK	Cummings	1996	8-10	≤-6/9	24.4	≤6/9	0.6
Hong Kong	Edwards	1997	7-12	≤-0.50	11.5	n/a	n/a

Study done in Japan showed that the prevalence of myopia increased from 43.5% at 12 years of age to 66% at 17 years of age.[26] The results of a study in Taiwan showed the incidence of myopia to be about 12% in children 6 years of age or less, 55% in children 12 years of age or less, 76% in children 15 years of age and 84% in those 16 to 18 years of age.[27]

In regards to distribution of refractive error by gender, various studies showed there was no statistically significant difference between males and females the patterns were less consistent. Some studies found a higher prevalence of refractive error in girls[17,24,29,30] while others in boys.[23] Other studies showed higher prevalence of myopia in girls[22,24,28] while others in boys[20,29]

In terms of geographic distribution, myopia is most prevalent in Africans in urban areas, hyperopia in rural areas in children aged 11 – 17 years old in Kenya and Malawi. In India urban children myopia was 3.16%, hyperopia 1.06%, astigmatism 0.16% compared to rural children with myopia 1.45%, hyperopia 0.39%, astigmatism 0.21%[31] (table 2). In Tanzania, Wedner et al found that in urban areas children were 5.6 times more myopic than rural area.[22]

Table 2: Prevalence of refractive error in Kenya (urban),[28] (rural),[29] Malawi (urban, rural)[30] India (urban, rural).[31]

Country	Reference	Year	Age range years	Significant refractive error	Prevalence myopia (%)	Prevalence hyperopia (%)	Prevalence astigmatism
Kenya urban	Nzuki	2006	11-17	< 6/12	9.4	0.3	0.5
Kenya rural	Muma	2007	12-15	< 6/18	1.7	3.2	0.3
Malawi urban	Msiska	2009	12-15	≤ 6/12	1.7	0.4	0.3
Malawi rural	Msiska	2009	12-15	≤ 6/12	0.8	1.4	0.1
India urban	Padhye	2009	6 – 16	< 6/12	3.16	1.06	0.16
India rural	Padhye	2009	6 – 16	< 6/12	1.45	0.39	0.21

The socioeconomic status of the children also influenced refractive errors distribution, several studies found more myopia in urban and developing areas, China, Singapore, United kingdom, Hong Kong.[25] In India urban children showed myopia 3.16%, hyperopia 1.06%, astigmatism 0.16% and in rural children myopia was 1.45%, hyperopia 0.39%, astigmatism 0.21%.[31] In Hong Kong Fan found children aged 11 years were almost 15 times more likely to have myopia than were children younger than 7 years.[32] The child with good socioeconomic status and urban areas were exposed constantly to electronic artifacts and near works.

2.4.0 IMPORTANCE OF REFRACTIVE ERROR CORRECTION IN CHILDREN

Children are defined as anyone less than 16 years of age according to UNICEF. WHO defines blindness as visual acuity in the better eye of less than 3/60, and severe visual impairment as a corrected visual acuity in the better eye of less than 6/60. The prevalence of childhood blindness

is estimated to be significantly 0.3 per 1000 children in the wealthy regions of the world to 1.5 per 1000 children in the poorer regions.[33]

The WHO - Vision 2020 Global Initiative has set a number of priorities focused on five major eye conditions which are preventable or treatable, these are cataract, trachoma, onchocerciasis childhood blindness and refractive error.

In February 1999, WHO suggested that priority actions be taken on the following: Elimination of Vitamin A deficiency, treatment of congenital cataract, glaucoma, retinopathy of pre-maturity, treatment of refractive errors and low vision.[34]

The most frequent complications of uncorrected hyperopia are: Accommodative convergent esotropia, due to excessive use of accommodation. Amblyopia due to anisometropia if is unilateral, ametropic if is bilateral or strabismic amblyopia if the child develops accommodative esotropia, predisposition to developing primary narrow angle glaucoma.

The most frequent complications of uncorrected myopia principally with pathological myopia are abnormal accommodation convergence reflex, squint and amblyopia. The retina becomes very thin and is stretched at the periphery; it has risk of developing defects like tears or holes and consequently retinal detachment. Progressive scarring of the retina and its underlying layers causes a chronic diminution of vision called Chorioretinal atrophy, Nuclear sclerosis, Choroidal hemorrhage, thrombosis and predisposition to developing primary open angle glaucoma.[7]

2.5.0 CORRECTION OF AMETROPIA IN CHILDREN SCHOOL AGED

2.5.1 SPECTACLES

Spectacles offer the easiest and economical solution to refractive errors and risk of blindness. They are suitable for all ages and all types of refractive errors. The disadvantage of using spectacles is that they offer a narrow field of vision and may be an obstacle for certain outdoor activities such as sports principally in children.

2.5.1.1 Myopia

The optical treatment of myopia is giving the appropriate prescription of concave lenses and preventing overcorrection. Usually myopia manifesting itself between 7-10 years should have

frequent refractions every 6 to 12 months because the myopia is progressive. To correct simple myopia (up to -6.0 D) children younger than 8 years should be fully corrected and advised to use their glasses constantly to avoid developing the habit of squinting and to enhance development of normal accommodative convergence reflex. The optical correction in the form of bifocal, multifocal spectacles or removal of distance spectacles when performing close work has been recommended to reduce accommodation, because the accommodation is a postulated mechanism for the progression of myopia. Intentional overcorrection of myopic error or undercorrection of a hyperopic can be of some value in controlling intermittent exodeviations. The prognosis is good. The error does not progress beyond 6-8 D and stabilizes by the eye of 21 years.[4,7]

In high myopia, full correction can rarely be tolerated especially if greater than -10.0 D. One should under correct for comfort of vision.[7]

2.5.1.2 Hyperopia

Appropriate correction of hyperopia is more complex than myopic. Total amount should always be discovered under complete cyclopegic refraction. Small refractive error +1.0 D or less, correction is given only if the patient is symptomatic. The older children may not accept full cyclopegic refraction because of blurring of distant vision. Always first undercorrect and prescribe the glasses that the child accepts comfortably. The full refractive correction may cause blurring of distance vision because of inability to relax accommodation fully.[4,7]

2.5.1.3 Astigmatism

The optical treatment of regular astigmatism is to prescribe appropriate cylindrical lens. Small astigmatism of 0.5 D or less should be treated only, if producing asthenopic symptoms or deterioration of vision. High astigmatism should be corrected fully; if the patient does not accept full correction for the first time, he should be under corrected until the patient is accustomed to the cylinder.[7]

2.5.2 CONTACT LENSES

Contact lenses are indicated in high myopia because spectacles may cause image distortion and patients rarely tolerate more than -10 D. Some authors report that perhaps hard contact lenses also slow down the progress of myopia. They may also be used in unilateral hyperopia

(anisometropia), ectatic disorders (keratoconus, pellucid marginal degenerations) and for cosmetic reasons. In irregular astigmatism contact lenses replace the anterior surface of the cornea. Contacts lenses are available in either soft or rigid types according to the requirements of the patient.

2.5.3 SURGERY

2.5.3.1 Implantation of Intraocular lens

Implanting an artificial lens is the optimal form of aphakic correction. Correction with aphakic spectacles can produce a number of difficulties, including image magnification, ring scotoma, peripheral distortion, a "Jack-in-the-box" phenomenon and a decreased useful peripheral field.[35]

2.5.3.2 Refractive Surgery

Although laser refractive surgery is only approved by the Food and Drug Administration for people 18 years and older, there are some instances in which refractive surgery is appropriate for children. For example, in children with bilateral high refractive error or unilateral severe anisometropia with amblyopia who cannot wear glasses or contact lenses, refractive surgery can be used as a last resort.[36]

Astle in Canada published a study of 40 eyes (27 children) in which photorefractive keratectomy (PRK) successfully treated myopia as high as -25.0 D. At one year post PRK these patients improved 20/70 to 20/40, and the main spherical equivalent (SE) decreased from -10.68 D to -1.37 D. Laser subepithelial keratomileusis (LASEK) in 36 eyes (25 patients), the mean SE decreased from -8.03 D to -1.19 D, most eyes (78%) had clear corneas immediately after LASEK.[37]

Therefore High myopia in children has been effectively treated with PRK. LASEK was effective in anisometropic amblyopia. LASEK is helpful in aphakic children and combined with strabismus surgery was successful in restoring vision and fusion. Laser in situ keratomileusis (LASIK) was safe and effective in correcting high hyperopic anisometropia.[37]

2.6.0 STUDY DEFINITIONS

- **Anisometropia**: Anisometropia is the condition in which the refractive error of one eye differs from the other. It may be characterized by unequal amounts of myopia or hyperopia, or one eye may be myopic and the other hyperopic, to which the special term antimetropia is applied. When the inequality is greater than 2 D, the anisometropia is considered of high degree.[16]
- **Amblyopia:** Is a unilateral or less commonly bilateral reduction of best-corrected visual acuity that cannot be attributed directly to the effect of any structural abnormality of the eye or the posterior visual pathways.[38]
- **Aphakia:** Absence of the lens of the eye, due to surgical removal, a perforating wound or ulcer, or congenital anomaly.[39]
- **Blindness:** WHO was defined internationally as a VA of less than 3/60 (20/400. 0.05) in the better eye with best possible correction, or a visual field loss in each eye to less than 10^0 from fixation. Corresponding to categories of visual impairment 3,4 and 5.[40]
- **Children:** Defined as younger than 16 years old according to UNICEF.[33]
- **Significant Refractive error:** For children less than 6/12 binocularly recommended as the criterion for a full refraction and correction.[25]
- **Low vision:** Defined as VA of less than 6/18 but equal to or better than 3/60.[40]
- **Nystagmus:** Is a repetitive, involuntary to and fro oscillation of the eyes which may be physiological or pathological.
- **Significant myopia:** Defined $\leq$ - 0.50 D.[25]
- **Significant hyperopia:** Defined $\geq$ +2.00 D.[25]
- **Significant astigmatism:** More than +/- 0.50 D
- **Strabismus:** Any deviation of the eye.

3.0 RATIONALE:

Uncorrected refractive error in school aged children is a public health concern in Cusco Peru. With this uncorrected refractive error the child cannot perform school activities, this adversely affects the child‘s education, occupation and socio-economic status later in life. Fortunately refractive error is easily treatable by inexpensive spherical or cylindrical spectacles. The most accessible and acceptable way to correct the visual disorder in children is to do vision screening in the schools to identify cases and to provide the spectacles freely or at low cost by National “Health Eye Program” in Peru.

There is no baseline data at national level on the prevalence of refractive error in high school aged students and benefit of free spectacles. This information is of high relevance for future planning at the national level to prevent the avoidable causes of blindness in Peru.

This study will provide baseline data on the prevalence of the refractive error at public high school students with low resources therefore this assessment will give us the magnitude of refractive errors in high school students in Cusco - Peru.

4.0 OBJECTIVES

4.1.0 GENERAL OBJECTIVE

To determine the prevalence and pattern of refractive errors in public high school students in Cusco province, Peru.

4.2.0 SPECIFIC OBJECTIVES

1. To determine the prevalence of refractive errors in public high school students using a random sample in Cusco province in Peru.
2. To determine the pattern of different types of refractive error in the sample study population.
3. To determine the proportions of uncorrected refractive error in study population.

Figure 1: Peru map showing department of Cusco

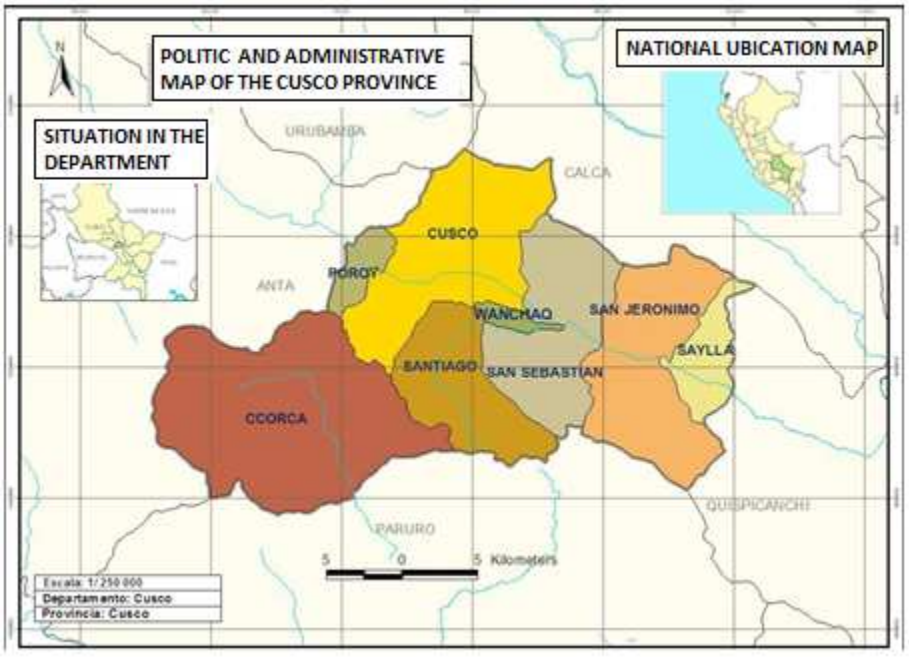

Figure 2: Cusco province conformed for eight districts

5.0 METHODOLOGY

5.1.0 Study design

A cross - sectional school based study

5.2.0 Study Setting

The study was done in high schools in Cusco Province of Peru. The total population in the province of Cusco was 367,191 which 25,692 students in public high schools according national data[41]. There were 47 public high schools. All the schools are situated in urban area of Cusco. The average of student's age in high schools of Cusco was between 12 to 16 years old.

5.3.0 Study population

Public High school students in Cusco province, Peru.

5.4.0 Study period

Proposal approval was obtained in September 2013 at the KNH/UoN Ethical Research Committee and by Ministry of Education in Peru in October 2014. The data collection period was from 29th October 2013 to 06th December 2013.

5.5.0 Case Definition

For this study, the WHO definition of significant refractive error was used.[25] High School students with visual acuity less than 6/12 (0.30) in at least one eye undergo objective and subjective refraction after ocular motility, anterior and posterior segment examination.

.5.6.0 Sample size calculation

To calculate the required sample size, the following parameters were used:

1. Estimate of the expected proportion (*p*)
2. Desired level of absolute precision (*d*)
3. Estimated design effect (*DEFF*)

4. Confidence limit (usually 95% and Z score = 1.96)

The sample size formula is:

$$n = \frac{1.96^2\, p(1-p)(DEFF)}{d^2}$$

$$n = \frac{1.96^2 \text{ x } 0.1 \text{ x } 0.9\ (1.5)}{0.02^2}$$

n = 1297

To estimate the assumed prevalence of refractive error 10% with 95% CI (8% - 12%) among high school students, adjusting for the design effect of 1.5 and confidence limit (usually 95% and Z score = 1.96), the final minimal sample size was 1297. For this study 1537 students was examined.

5.7.0 Sampling method

Public high schools were arranged by probability proportional to size. Within each type of school, simple random sampling was used to select the required number of schools. Random number was generated by a computer. All the students from the 3 selected mixed secondary schools were included in the study. Students from the selected boys and girls schools were selected randomly to complete the number of sample size.

Table 3: Sampling frame of high school students in Cusco province:

Type of school	Total schools	Median	Mean	Min.	Max.	Children total	%	Required children	Schools	Planned
Boys	4	825.5	1076.8	58	2598	4307	16.8	252	0.31	1
Girls	6	754	866.5	240	1303	5199	20.2	303	0.40	1
Mixed	37	350	437.5	87	1483	16186	63	945	2.70	3
Total	47	367	793.6	58	2598	25692	100	1500	4.09	5

5.8.0 Inclusion criteria

All the students from randomly selected 5 schools with full consent of school head teacher.

5.9.0 Exclusion criteria

Students with other ocular pathologies that reduces visual acuity.

5.10.0 Visual screening and refraction procedure

Consent was obtained from the administration of each of the participating schools, from the parents and from the participants. Lists of the students were taken by the researcher from the registered book of the school to ensure the exact participatory response rate of the children of that school.

Demographic data of each student was obtained. History of correction with spectacles was obtained and family history of use spectacle correction was also obtained for those students with refractive error. Visual acuity was assessed using designed LogMAR chart at three meters. For students who wore spectacles, visual acuity was taken without correction and with correction. All the students with visual acuity worse than 6/12 (0.30) without spectacles were included in the study. Non cyclopegic objective refraction was done by retinoscopy in a darkened room, followed by subjective refraction. For students who wore spectacles was taken the power of the spectacles using a Lensometer. An ocular examination using a torch, direct or indirect ophthalmoscope was performed. All the students' biodata and examination findings were recorded in a questionnaire. The student with other ocular pathologies that reduces visual acuity was referred to the local Hospitals. The type of refractive error after refraction was grouped into myopia, hypermetropia or astigmatism. Prescriptions were given to those students who needed spectacles.

5.11.0 Data analysis

All data was analyzed using the SPSS version 17 statistical software. Results were presented using ratio, proportion, rates, tables and diagrams wherever appropriate. 95% confidence interval was calculated for the prevalence.

6.0 ETHICAL CONSIDERATIONS

1. Confidentially of students records was observed.
2. Correction and follow up was recommended for all the students with refractive error.
3. For objective refraction only medications approved by the Ministry of Health of Peru was used. Side effects were explained.
4. Approval was sought from Ethical Committee of University of Nairobi – Kenyatta National Hospital in Nairobi Kenya and from the Peru Ministry of Education (Local Educational Management Unit, DRE/UGEL Cusco).
5. Permission from headmaster of schools were obtained
6. Consent was obtained from children parent's/guardians and from participants (assent).
7. Students with other ocular disease were referred to local hospitals.

7.0 MATERIALS

1. Retinoscopes
2. Ophthalmoscopes (direct and indirect)
3. Torches
4. LogMAR charts
5. Refraction set and trial frames
6. 20 D loupe
7. Lensometer
8. Dilating eye drops (mydriacyl)
9. Spectacle prescription papers and referral papers
10. Data collection forms

8.0 THE STUDY TEAM

The medical team included principal investigator, local ophthalmologist (supervisor) from San Juan de Dios Hospital of Cusco and two ophthalmic nurses.

9.0 RESULTS

A total of five urban public high schools were visited to screen high school students for refractive errors. They comprised of three mixed schools (male and female), one male school and one female school with a total number of 1752 registered students.

Out of the 1752 registered students, only 1537 were present in school during the study period. The average response rate was determined to be 87.7% (Table 4).

Table 4: Participation response rate of students during survey

School	**Type of school**	**Students registered**	**Students present and examined**	**Response rate**
Cecilia Tupac Amaru	Mixed	346	286	82.6%
Nuestra señora de la Natividad	Mixed	124	100	80.6%
Ciencias	Boys	284	253	89.1%
Diego Quispe Tito	Mixed	710	622	87.6%
Educandas	Girls	288	276	95.8%
Total	**5**	**1752**	**1537**	**87.7%**

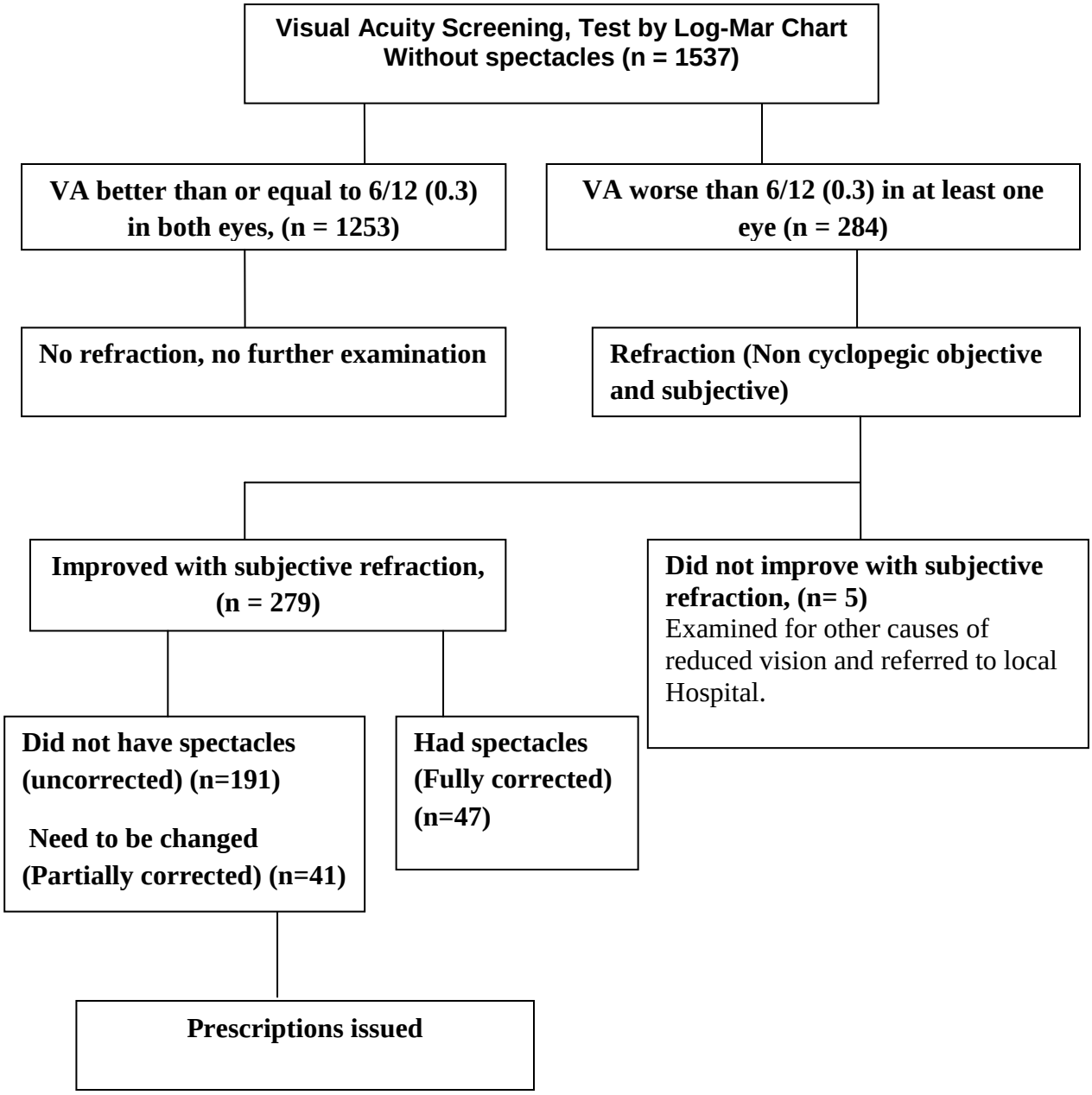

Figure 3: Flow chart of examination process

Out of the 1537 respondents, 284 students had VA worse than 6/12 at least one eye, and of the 284, 279 had refractive errors.

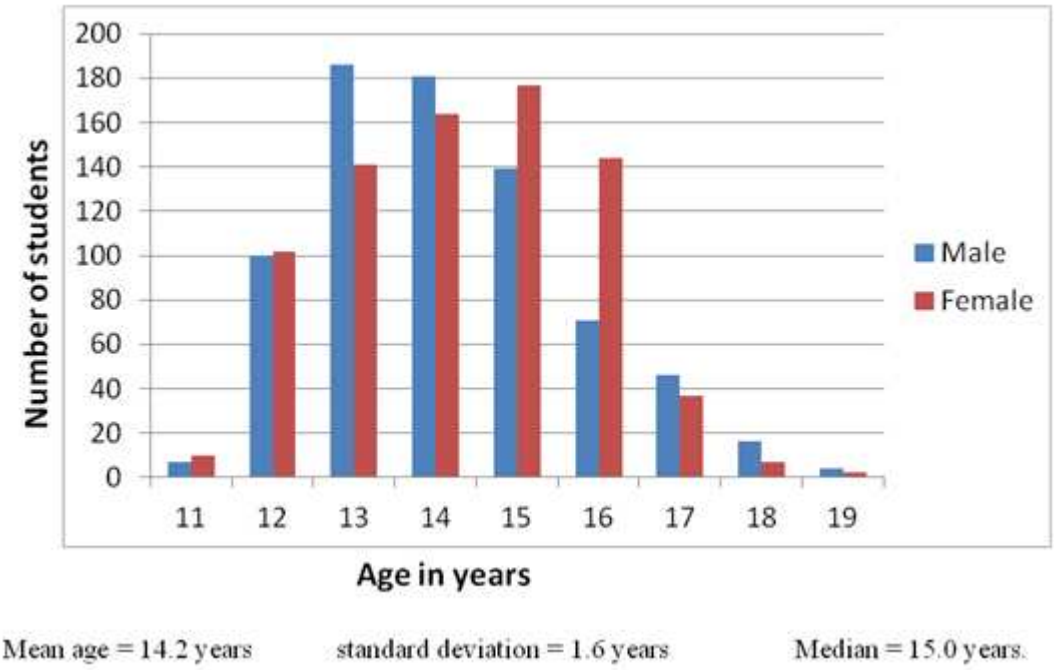

Figure 4: Distribution by age and sex of study population (n = 1537)

Majority of the study participants were between 12 to 16 years (91.4%). The distribution by sex was 785 (51.1%) female and 752 (48.9%) male students.

Table 5: Presenting Visual acuity in the better eye according WHO categorization of blindness and visual impairment (n = 1537)

Category	Visual acuity	Number of students	Percentage
0	6/6 - 6/18	1486	96.7
1	<6/18 - 6/60	51	3.3
2	<6/60 - 3/60	0	0
3	Worse than 3/60	0	0

Majority of students had normal vision (Category 0) in the better eye 96.7 % and 3.3% had moderate visual impairment.

Table 6: Visual acuity status by sex (n = 1537)

Visual acuity	Frequency (%)	Female (%)	Male (%)	OR (95%)	P-value
Worse than 6/12	284 (18.5)	179 (22.8)	105 (14.0)	1.8 (1.4-2.4)	<0.001
Better than or equal to 6/12	1253 (81.5)	606 (77.2)	647 (86.0)	1.0	

The females had 1.8 times visual impairment (visual acuity worse than 6/12) than males, OR 1.8 (95% CI 1.4-2.4). This difference was statistically significant with p<0.001.

Table 7: Laterality of visual acuity worse than 6/12 (n = 284)

Characteristic	Frequency	Percentage
Bilateral	162	57.0
Unilateral	122	43.0

Out of the 284 students with visual acuity worse than 6/12, 57% of the students had bilateral involvement.

REFRACTIVE STATUS

Table 8: Prevalence of refractive error (n = 1537)

Variable	Frequency	Percentage
Refractive error	279	18.2
No refractive error	1258	81.8

The prevalence of refractive errors was 18.2%.

Table 9: Laterality of refractive error (n = 279)

Characteristic	Frequency	Percentage
Bilateral	162	58.1
Unilateral	117	41.9

58.1% of the students with refractive error had bilateral involvement compared to 41.9% who had unilateral refractive error.

Table 10: Type of refractive error (n = 1537)

Type	Frequency	Percentage
Astigmatism	224	14.6
Myopic	126	8.2
Hyperopic	12	0.8
Mixed	86	5.6
Myopia	53	3.4
Hypermetropia	2	0.1
No refractive error	1258	81.9

Myopic astigmatism was the most frequent refractive error at 8.2%.

Table 11: Distribution of refractive errors by sex (n = 279)

Variable	Female (%)	Male (%)	OR (95%)	P-value
Astigmatism	136 (76.4)	88(87.1)	0.5 (0.2-1.0)	0.025
Myopia	40 (22.5)	13 (12.9)	2.0 (1.0-4.0)	0.041
Hypermetropia	2 (1.1)	0 (0.0)	-	0.286
TOTAL	178 (100.0)	101 (100.0)		

There was statistically significant association between astigmatism and sex of the students (p=0.025). There was statistically significant association between myopia and sex of the students (p=0.41).

Table 12: Distribution of refractive errors by age groups (n = 279)

Variable	Age groups				P-value
	11 to 12	13 to 14	15 to 16	17 to 19	
Astigmatism	36 (81.8)	92 (84.4)	80 (75.5)	16 (80.0)	0.077
Myopia	7 (15.9)	17 (15.6)	26 (24.5)	3 (15.0)	0.062
Hypermetropia	1 (2.3)	0 (0.0)	0 (0.0)	1 (5.0)	0.743
Total	44 (100.0)	109 (100.0)	106 (100.0)	20 (100.0)	

There was no significant association between astigmatism and age groups distribution (p=0.077).

There was no significant association between myopia and age groups distribution (p=0.062).

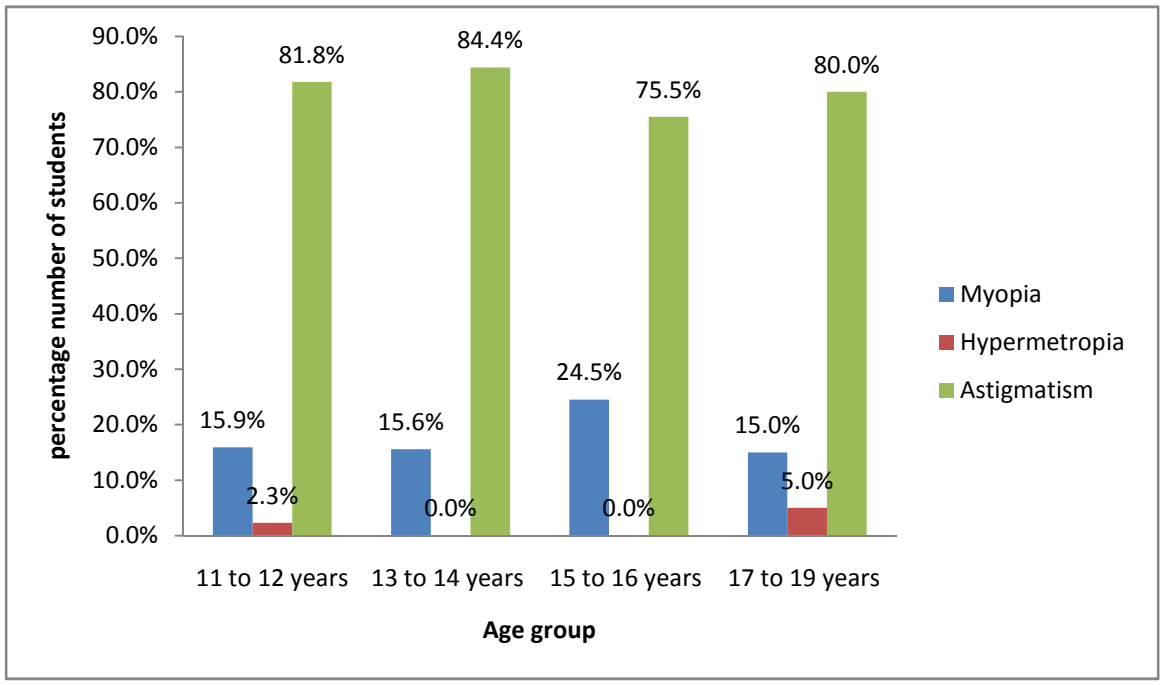

Figure 5: Distribution of refractive error by age groups

The frequency of astigmatism was higher in all age groups and was almost similar distribution.

Table 13: Laterality and lens power distribution among students with refractive error (n=279)

Variable		Bilateral	Unilateral	Total
Myopia	-0.50 to -2.00DS	39(13.9)	1(0.4)	40(14.3)
	-2.25 to -4.00DS	9(3.2)	0(0.0)	9(3.2)
	-4.25 to -6.00DS	3(1.1)	0(0.0)	3(1.1)
	Greater than -6.00DS	0(0.0)	1(0.4)	1(0.4)
Astigmatism (cylinder)	-0.50 to -2.00DC	68(24.4)	9(3.2)	77(27.6)
	-2.25 to -4.00DC	46(16.5)	49(17.6)	95(34.2)
	-4.25 to -6.00DC	22(7.9)	25(9.0)	47(16.9)
	Greater than -6.00DC	2(0.7)	3(1.1)	5(1.8)
Hyperopia	+2.00	2(0.7)	0(0.0)	2(0.7)
Total		**191(68.5)**	**88(31.7)**	**279(100.0)**

Majority of the students in each type of refractive error had bilateral involvement.

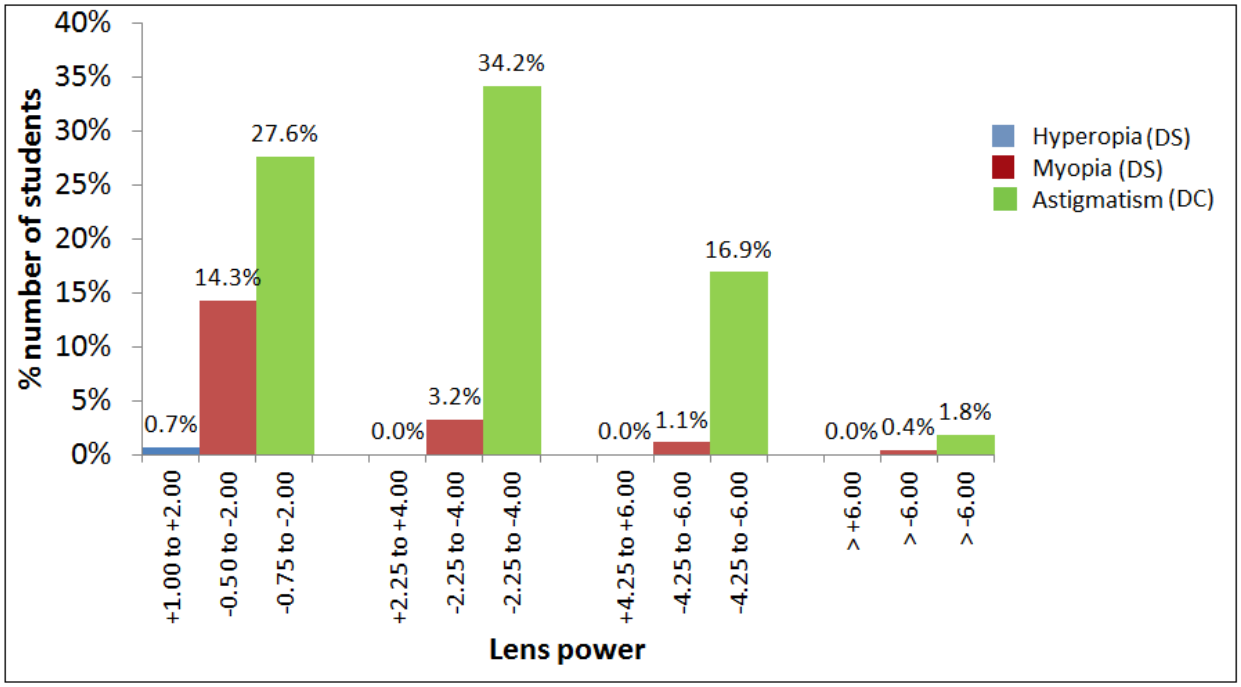

Figure 6: Lens power distribution among students with myopia and astigmatism

Majority of the students with myopia having lens power between -0.50 to -2.00 DS and who having astigmatism majority was between -2.25 to –4.00DC.

NEED FOR REFRACTIVE SERVICE

Table 14: Spectacle correction among the students with refractive errors (n = 279)

Refractive error	Bilateral	Unilateral	Total
Fully corrected	45(16.1)	2(0.7)	47(16.8)
Partially corrected	24(8.6)	17(6.1)	41(14.7)
Uncorrected	93(33.3)	98(35.1)	191(68.5)
Total	**162(58.1)**	**117(41.9)**	**279(100.0)**

*The proportion of uncorrected refractive error was 12.4% (191/1537).

In this study 16.8% of the students with refractive errors were wearing full spectacle correction hence they did not need a change of spectacles. However, 83.1% needed new spectacles because they either did not have spectacles or had spectacles which needed to be changed (partially corrected).

Table 15: Need for spectacles by sex (n = 279)

Need for spectacles	Sex	
	Female	Male
Does not need:		
Fully corrected	34 (19.1)	13 (12.9)
Need spectacles:		
Partially corrected	32 (18.0)	9 (8.9)
Uncorrected	112 (62.9)	79 (78.2)
Total	178 (100.0)	101(100.0)

There were more female wearing full spectacle corrections than male.

BARRIERS TO USING SPECTACLES

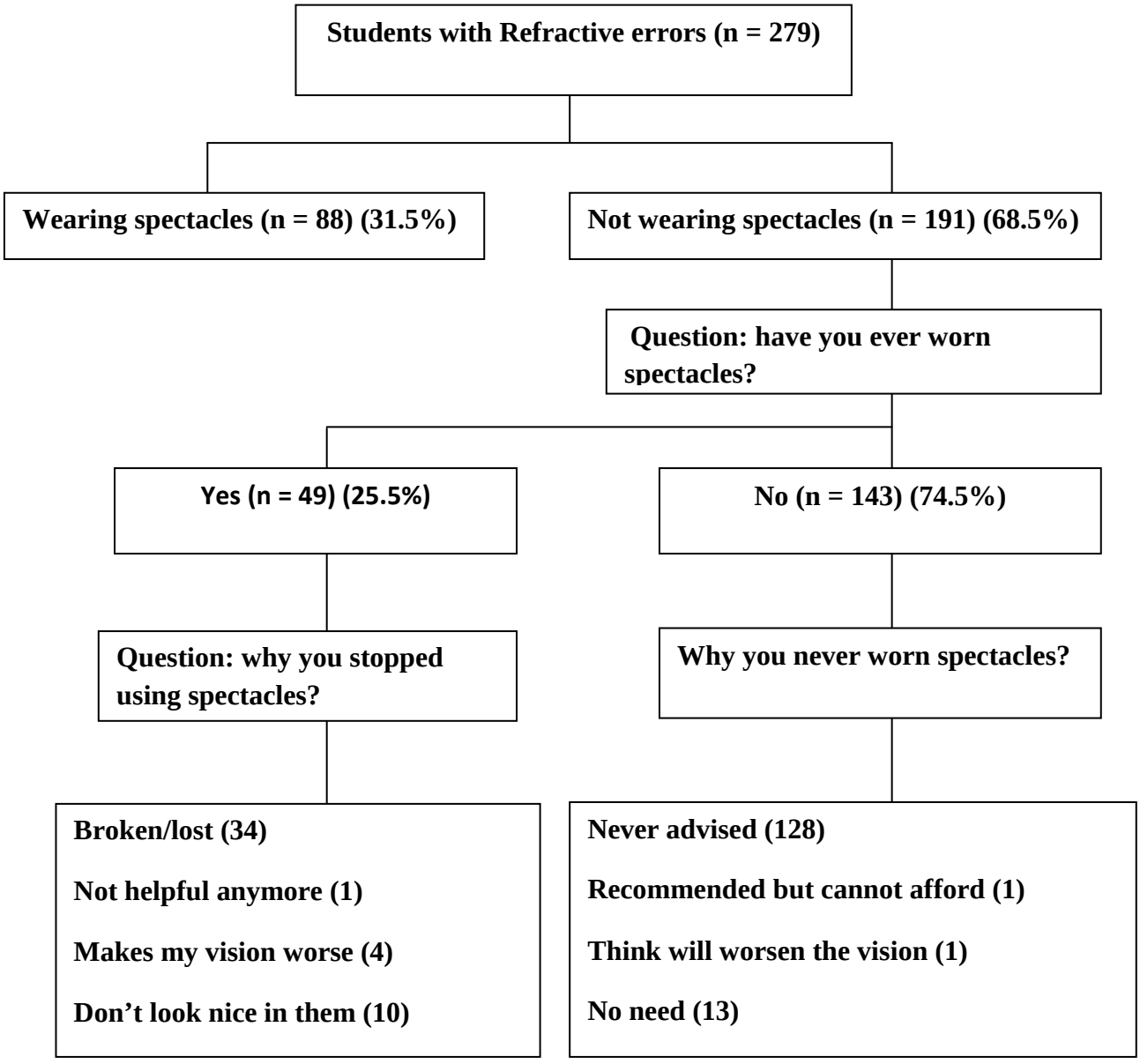

Figure 7: Flow chart of reasons why not wearing spectacles

Of out 279 participants having refractive error only 88 (31.5%) students were wearing spectacles.

Table 16: Reasons why stopped wearing full spectacle correction having refractive error by sex (n =49)

Reason	Female (%)	Male (%)	Total (%)
Broken/lost	24 (68.6)	10 (71.4)	34 (69.4)
Not helpful anymore	1 (2.9)	0 (0.0)	1 (2.0)
Make the vision worse	3 (8.6)	1 (7.1)	4 (8.2)
Don't look nice in them	7 (20.0)	3 (21.4)	10 (20.4)
Total	**35 (100.0)**	**14 (100.0)**	**49(100.0)**

Majority 69.4% stopped using spectacles because the spectacles got broken or lost.

Table 17: Reasons why never worn spectacle correction having refractive error by sex (n = 143)

Reason	Female (%)	Male (%)	Total (%)
Never advised	65 (85.3)	63 (94)	128 (89.5)
Recommended but cannot afford	1 (1.3)	0 (0.0)	1 (0.7)
Think will worsen the vision	1 (1.3)	0 (0.0)	1 (0.7)
No need	9 (12)	4 (6.0)	13 (9.2)
Total	**76 (100.0)**	**67 (100.0)**	**143(100.0)**

Majority of the students were never advised to wear spectacles correction 89.5%.

FAMILY HISTORY OF WEARING SPECTACLES

Table 18: Family history of wearing spectacles correction for far vision, among students with refractive errors (n = 279)

Family member	Frequency	Percentage
Parent	52	18.6
Sibling	36	12.9
Parent/sibling	18	6.5
None	173	62.0

Majority of the students having refractive error (62%) did not have family history.

11.0 DISCUSSION

The study investigated the prevalence of refractive error among high school students in Cusco province, Peru. A total of 1752 school students were identified from official register books at each school, of which 1537 students present during the survey day were screened (table 4). The findings indicate that the prevalence of refractive error was 18.2% (table 8). Astigmatism was the leading prevalent type of refractive error at 14.6% followed by myopia (3.4%) and the least was hypermetropia (0.1%), (table 10). The proportion of uncorrected refractive error was 12.4% (table 14).

In our study found out that refractive error (18.2%) was the main cause of visual impairment (table 10). This was higher compared to other studies done by Zhao in China[19] and Maul in Chile[20] who found the prevalence to be 11.3% and 9.8% respectively among the school going children. This study considered the definition of significant refractive error as recommended by WHO[25]. In this study the prevalence was higher maybe due to the locality of study population which was in an urban setting compared to those studies in China and Chile which were in rural area and sub urban areas respectively. Another reason may be attributed to the age groups of the study participants since those studies included up to 15 years old children while in our study the population ranged between 11 to 19 years though most of them were between 12 to 16 years. The finding of the prevalence of refractive error in our study was almost similar to findings from other studies done by Goh et al in Malaysia and Pokharel et al in Nepal who found a prevalence of 20.2% and 19.8% respectively. This may be attributed to similar race/ethnicity in the study group. Another study conducted by Sethy et al in Ahmedabad city found high prevalence of refractive error (25.3%) in school age children between 12 to 17 years; this finding was probably due to study definition that included children for refraction with VA less than 6/9 in either eye.[23]

A low prevalence of refractive error (3.0%) was found by Costa et al in Bangladesh[24] possibly because they considered a visual acuity of less than 6/12 in the better eye while this study considered in at least one eye. Studies conducted among the African population by Nzuki et al and Muma in Kenya, and Msiska in Malawi found lower prevalence of refractive error of 10.2%, 4.2% and 2.4% respectively.[28, 29, 30] The lower prevalence compared to findings of this study could be attributed to racial and ethnic differences.[25] This also explains the generally low prevalence of refractive errors in sub-Saharan Africa.[25, 28, 29, 30] Other explanations for the

differences in prevalence may be explained by the fact that urban dwelling students tend to have a higher prevalence of refractive error [23, 28, 31, 42, 43] than those from rural areas. [19, 29, 30, 31, 43, 47] The variability of the definitions used in different studies for study screening makes for the difference in the results.

In our study found out that the prevalence of astigmatism, myopia and hypermetropia was 14.6%, 3.5% and 0.1% respectively (table 10). Sethi in Pakistan found astigmatism to be 6.0%, myopia 3.6% and hypermetropia 3.2%.[17] Hossain et al in Bogra city of Bangladesh found almost similar prevalence in children with astigmatism to be 10.1% followed by myopia and hyperopia at 9.2% and 2.0% respectively.[44] These trends are replicated in our study probably due to similarity in specific study population as age distribution and socioeconomic status of these countries are concerned. Latin America does not have many studies on refractive error. However a study conducted by Solano et al in Bogota, Colombia in children aged between 4 to 9 years of age found astigmatism at 15.1%, followed by hypermetropia 13.8% and myopia 2.3%.[45] Compared to our study the astigmatism is similar and the leading type of refractive error may be due to similar Hispanic racial-ethnicity. An observational study in children from 4 ethnic groups, conducted by Kleinstein et al had reported that Asians and Hispanics had the highest prevalence of astigmatism.[46]

In our study, myopia was the second most prevalent type of refractive error at 3.5% and this seems to coincide with other studies conducted by Sethy in Pakistan, Muma in Kenya and Hussain in Bogra.[17, 29, 44] However findings from some studies from different countries like China,[19] Chile,[20] Kenya,[28] Malawi,[30] India,[23, 24, 31] and Nepal [43] have shown that it was the most common type of refractive error. Myopia is usually a common type of refractive error among children older than 6 years hence these results.[4]

In our study, hypermetropia was least prevalent with only 0.1% (table 10). This is consistent with other studies in similar age group population and in most of the similar studies that were done in urban areas which reflect the same finding. Similar low prevalence was found in many studies done in urban areas[17, 20, 28, 30, 31, 42] and in rural areas have also shown a similar trend.[29, 31, 43, 47] This consistent lower prevalence of hypermetropia in school going children is due to the emmetropization process of the eye and the children experience loss of hypermetropia after 6 to 8 years of age.[5, 47]

The distribution of the common type of refractive errors was explored among the gender of the study participants. Astigmatism was significantly higher in males (87.1%) than in females (76.0%) p = 0.02. Myopia was significantly higher in females (22.9%) than males (12.9%) which a p-value = 0.049 and the females were 2 times more likely to have Myopia than males (table 11). Hypermetropia was found only in females (1.1%), (table 11). In other studies, pattern by sex are less consistent, some studies found a higher prevalence of refractive error in girls[17,24,29,30] while others in boys.[23] Other studies also showed higher prevalence of myopia in girls[22,24,28,45] while others in boys.[20,29] Solano et al in Colombia found higher prevalence of astigmatism and hypermetropia in boys.[45]

There was no statistically significant association between each type of refractive error and age groups distribution among 11 to 19 years old students (p-value = 0.075), (table 12). A study in Chile found that myopia was significantly associated with age.[20] A study by Matsumura in Japan also found out that myopia increases with age from 43.55% at 12 years of age to 66% at 17 years of age.[26] The results of the study in Taiwan showed the incidence of myopia to be about 12% in children 6 years of age or less, 55% in children 12 years of age or less, 76% in children 15 years of age and 84% in those 16 to 18 years of age.[27] Pokharel et al study in Nepal also found myopia increasing with age.[43] A study by Dandona et al found a gradual shift towards less positive values of refractive error occurred with increasing age in both boys and girls.[47] These studies support the natural development of the human optical system.[4]

The definition of uncorrected refractive errors varies among various studies. In our study it was defined as participants with refractive errors not wearing any spectacle correction. Partially corrected was defined as participants with refractive error wearing spectacles, who after subjective refraction improved by two or more lines. We found out that the overall prevalence of uncorrected refractive error was 12.4% (191/1537), (table 14). Previous population-based studies reported approximately similar findings while some studies have reported higher prevalence than other studies. Zhao in China reported a prevalence of 12.8%;[19] while Maul in Chile reported 15.8%;[20] and Padhye in India 5.5%[31] Ho et al in Singapore reported the prevalence of uncorrected refractive error was 22.3%; and was defined as improvement of at least 0.2 LogMAR in best visual acuity after subjective refraction.[48] Ostadighaddam et al in Iran reported

the prevalence of uncorrected refractive error was 6.2% in at least one eye; who defined the uncorrected refractive error as an improvement in BCVA of at least 2 lines compared to the presenting VA[49]. These findings may be attributed to the fact that the definitions for uncorrected refractive error are not consistent due to limited current information.

In our study we found that majority of the students had bilateral refractive errors (68.5%), (table 16). Almost similar finding was found by Muma et al in Kenya at (77.3%) that presented with bilateral refractive errors.[29] In our study most of the participants with myopia had lens power between -0.50 to -2.00 DS (14.3%) and for those who had astigmatism majority were between -2.25 to –4.00DC (34.2%), (figure 6). Compared to a study conducted by Costa in Bangladesh that found similar distribution of myopia with most of the students having lens power between -0.25 to -2.00DS.[24]

Of the 279 students with refractive error; 191 (68.5%) were not using spectacles, while 88 (31.5%) students were wearing spectacle correction and of those 47 were fully corrected and 41 partially corrected (figure 7). The study by Nzuki et al found 11.2% of the students had full spectacle correction and 77.3% had uncorrected refractive error[28]. The findings show a similar trend probably because they are both done in urban setting with comparable socioeconomic factor.

The 279 students with refractive errors were asked about their family history of wearing spectacles correction for far vision among family members of first degree (father, mother and/or sibling). Majority of the students (62%) had refractive errors without any family member wearing spectacle correction. Only 25.1% and 12.9% of the students had parental and sibling association respectively (table 18).

This parental association of wearing spectacles correction for refractive error supports a role for heredity and susceptibility in myopia, progression and eye growth. [9, 10,] A study conducted by Ali in Pakistan reported a positive familial history of wearing spectacles at 57% and indicates a very strong relationship between refractive errors and hereditary or familial factors.[50] Another study conducted by Rohul in India reported 31% had a positive family history of refractive error and the relationship was highest in myopics.[51] In our study positive family history was 37.9%

almost similar to those studies probable due to similar socioeconomic status and ethnicity factors.

In this study the high prevalence of refractive error and uncorrected refractive error among school children is a public health concern. Astigmatism was the leading type of refractive error and mainly the myopic astigmatism. The lens power in the different types of refractive error found low hypermetropia, astigmatism between -0.75 to -4.00DC and in myopics simple myopia was in most of the students. The lens power distribution of each type of refractive error was bilateral involvement in the majority of the students. The students with refractive error who needed new spectacles were at 83.1% because they were not corrected or were partially corrected. Broken/lost and lack of previous eye exam (never advised) were the main reasons why those students having refractive errors were not using spectacles. Finally only 38% of the participants had a positive direct family history of wearing spectacles for far vision.

11.0 CONCLUSION

The prevalence of refractive errors in Cusco – Peru among urban high school students was high at 18.2% and the prevalence of uncorrected refractive error was significantly high at 12.6%.

Astigmatism was the most prevalent refractive error at 14.6%

Astigmatism was more prevalent in males than females and myopia was more prevalent in females than males.

The proportion of students with refractive errors who were not wearing spectacles correction was 68.5%

Broken or lost spectacles was the most common reason for not wearing spectacle correction among students who had spectacle correction before (69.4%).

Most of the students with refractive errors were not wearing spectacles because they were never advised/examined before (89.5%).

12.0 RECOMMENDATIONS

A routine school student screening and examination should be conducted annually by eye health program in all of the country.

Provide information to the parents about refractive error and advise them to take the children to eye care centers and therefore avoid visual impairment and blindness.

The national health program should provide low cost spectacles services.

13.0 STUDY LIMITATIONS

One school did not have free accessibility during the screening period because of the end year exams period and only had one hour available per day, therefore it was impossible to proceed and a replacement school was selected randomly from the remaining list.

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15.0 APPENDICES

Appendix 1: Questionnaire

Section A: Data collection Form

Study of ametropia in public high school students, in Cusco province, Peru.

Date: ☐☐☐ Study number: ☐☐☐☐☐☐

Name of the school: _____

Age: _____ Years Gender: Male ☐ Female ☐

Class: _____ Using spectacles: Yes ☐ No ☐

Power of spectacle:

Eye	Spherical	Cylindrical	Axis
RE			
LE			

Visual Acuity: Without spectacle correction: RE_____ LE _____

With spectacle correction: RE_____ LE _____

Reason for reduce vision:

Refractive error ☐ Cornea ☐ Lens ☐ Macula ☐ Retina ☐ Glaucoma ☐

Amblyopia ☐

Objective refraction:

Eye	Spherical	Cylindrical	Axis
RE			
LE			

Subjective refraction:

Eye	Spherical	Cylindrical	Axis
RE			
LE			

BCVA: RE_____ LE _____

Diagnosis:

Emmetropia: ☐

Type of refractive error: Myopia ☐ Hypermetropia ☐ Astigmatism ☐

Appendix 1: Questionnaire

Section B

Reasons for not using spectacles in students with refractive error and family history of wearing spectacles.

Study number: ☐

School: _____

1) Have you ever worn spectacles?

Yes ☐ No ☐

If yes: a) Duration _____

b) Why have you stopped using spectacles?

- ☐ Broken/lost
- ☐ Not helpful anymore
- ☐ Makes my vision worse
- ☐ Don't look nice in them

If No: a) Why?

- ☐ Never advised
- ☐ Recommended but cannot afford
- ☐ Think will worsen the vision
- ☐ No need

2) Family history of wearing spectacles:

- ☐ Father
- ☐ Mother
- ☐ Brother/sister

Appendix 2: Letter to Schools for seeking permission

Cusco, October 2013

To:

Headmaster/principal

_____

_____

Cusco - Peru.

Subject: Request for assessment of refractive errors.

I am, Dr. Teofilo Cordova Pumacahua is a Resident of Ophthalmology in the University of Nairobi – Kenya. I am from Cusco, CMP 41600. I am doing a research to find out the prevalence of Ametropia in high school students in Cusco province in cooperation with ophthalmology clinic of San Juan De Dios Hospital of Cusco. Your school has been selected to screen for this study. This study is not invasive and poses no risk for the student. It will also benefit students in a way of identifying those with refractive errors for correction with spectacles.

Therefore, I am earnestly requesting you to allow me to do the study, looking forward to a favorable response

Yours Sincerely.

Dr. Teofilo Cordova Pumacahua
Ophthalmology resident/University of Nairobi-Kenya
CMP 41600 / Tel: 0051 (84) 501850 (Cusco)

Dr. Jeisson Castro Loayza
Ophthalmologist at San Juan de Dios Hospital, Cusco-Peru
Email: jeisson555@hotmail.com
Tel: 979666610

Appendix 3: Consent explanation

Title of proposal: Prevalence of ametropia among public high school students in Cusco Province, Peru.

Introduction: I am, Dr. Teofilo Cordova Pumacahua is a second year Resident of Ophthalmology in the University of Nairobi – Kenya, Reg. No H58/71030/2011. I am from Cusco, CMP 41600. I am doing a research to find out the prevalence of Ametropia in high school students in Cusco province. My supervisors from University of Nairobi, Kenya are Dr. Margaret W Njuguna, Dr. Nyenze E Muindi. From San Juan De Dios Hospital of Cusco – Peru is Dr. Jeisson Castro Loayza.

What is Ametropia? Ametropia or Refractive error is a condition when light rays converge in front or behind the retina, as a consequence of this, images seen are blurred, which is sometimes so severe that it creates functional blindness for affected individuals. This condition can be myopia (short sight), hypermetropia (long sight) or both. The consequences of uncorrected refractive error include abnormal accommodation, headache, deviation of the eye, pathological myopia (short sight) and Amblyopia (lazy eye). Uncorrected refractive error is one of main causes of visual impairment in children. Therefore lifestyle is significantly affected; there is hampered performance at school, reduced employability and productivity. Correcting refractive errors in children is one of the priorities of the World Health Organization.

Purpose: In Cusco does not have a baseline data on the prevalence of refractive error in school going students. Usually the age of the high school students in Cusco is between 12 to 16 years old. Testing vision at school is good because most of the children in Cusco go to school. The treatment of refractive error is easy, cheap and most of the time is affordable by supplying spectacles. This information is of high relevance for future planning at the national level to prevent the avoidable causes of childhood blindness in Peru.

The objectives of the study: Is to determine the amount of refractive errors, the different types of refractive error and the proportions of uncorrected refractive error in public high school students in Cusco province.

Eye examination and procedure: We invite your child to participate in this study and students from the selected 5 high schools will be participating. Eye examination will included how well a student can see from a prescribed distance using standard reading chart. If the student will read less than 6/12 line in at least one eye he/she will undergo refraction (checking need for spectacles). The front part of the eye will be examined using a torch and the back part of the eye will be examined using direct ophthalmoscope. Those suspected to have pathology in the back part of the eye, a dilating eye drops (tropicamide 1%) will be used. These drops have not been associated with major side effects except a temporary blurring of vision and increased light sensitivity that resolves within 6 hours. The students found to have refractive errors will be prescribed spectacles correction and will be advised where to get affordable spectacles.

Benefits: The screening and examination of the students will be free. Students with refractive error will be recommended to use a spectacle correction, the prescription will be given and will be advised where to get glasses at affordable prices. The students with ocular pathologies will be referred to reference hospital for opportune management.

Risks: This study is not invasive and poses no risk for the students, but they may experience some discomfort from shining of the light into to their eyes and instillation of the eye drops.

Confidentiality: All personal information gathered from you as my participant in this research will be kept confidential and will be used for the purpose of demonstrating the objectives of study. Research data will be stored in a personal computer with computer protected password that only known to me. Any publication will not be having any identifiers.

Who to contact: For any information regarding your rights as a research participant you can contact; Prof A.N Guantai – Chair-Kenyatta National Hospital-University of Nairobi- ethics and research committee. Tel. +254-2726300, External 44102, Email: anguantai@yahoo.com. Or San Juan de Dios Hospital, Ophthalmology service, Av Manzanares 264 – Manuel Prado urbanization, Cusco- Peru, With the Ophthalmologist Dr. Jeisson Castro Loayza, Tel: 979666610, Email: jeisson555@hotmail.com.

Appendix 4: Consent form

Name of the school……..

Dear parents/Guardians

I am, Dr. Teofilo Cordova Pumacahua is a Resident of Ophthalmology in the University of Nairobi – Kenya. I am from Cusco, CMP 41600. I am doing a research to find out the prevalence of Ametropia in high school students in Cusco province in cooperation with ophthalmology clinic of San Juan De Dios Hospital of Cusco. The school where your child is studying has been selected to screen for this study. This study is not invasive and poses no risk for the student. It will also benefit students in a way of identifying those with refractive errors for correction with spectacles.

If you agree, please sign at the bottom or put a thumb print.

I agree that my child take part in the study ……. Date ……..

Witness (Head teacher) ……...

Dr. Teofilo Cordova Pumacahua
Ophthalmology resident/University of Nairobi-Kenya
CMP 41600 / Tel: 0051 (84) 501850 (Cusco)

Dr. Jeisson Castro Loayza
Ophthalmologist at San Juan de Dios Hospital, Cusco-Peru
Email: jeisson555@hotmail.com
Tel: 979666610

Appendix 5: Assent form

Name of the school……..

Dear participant

I am, Dr. Teofilo Cordova Pumacahua is a second year Resident of Ophthalmology in the University of Nairobi – Kenya. I am doing a research to find out the prevalence of Ametropia in high school students in Cusco province in cooperation with ophthalmology clinic of San Juan De Dios Hospital of Cusco. Your school has been selected to screen for this study. This study is not invasive and poses no risk. It will also benefit students in a way of identifying those with refractive errors for correction with spectacles.

If you agree, please sign at the bottom or put a thumb print.

I agree take part in the study ……. Date ……..

Witness (Head teacher) ……...

Dr. Teofilo Cordova Pumacahua
Ophthalmology resident/University of Nairobi-Kenya
CMP 41600 / Reg. H58/71030/2011
Tel: 0051 (84) 501850 (Cusco)

Dr. Jeisson Castro Loayza
Ophthalmologist at San Juan de Dios Hospital, Cusco-Peru
Email: jeisson555@hotmail.com
Tel: 979666610

Appendix 6: Letter to San Juan De Dios Hospital for seeking permission

Cusco, October 2013

To:

Director/principal

_____

_____

Cusco - Peru.

Subject: Requesting for instruments for refraction.

I am, Dr. Teofilo Cordova Pumacahua CMP 41600, a Resident of Ophthalmology in the University of Nairobi, Kenya and citizen from Cusco, Peru. I am doing a research to find out the prevalence of Ametropia in high school students in Cusco province in cooperation to Dr. Jeisson Castro Loayza ophthalmologist of San Juan De Dios Hospital of Cusco, who is my 3th supervisor for this study. During the survey I will require some instruments for refraction (refraction box, Lensometer) for this purpose and will returned after data collection. The data collection will be from 2nd September to 5th October of 2013. This study is not invasive and poses no risk for the student. It will also benefit students in a way of identifying those with refractive errors for correction with spectacles. Patients with other ocular pathologies will be referred to ophthalmologist for review at your Hospital.

Therefore, I am earnestly requesting you to allow me the instruments to enable me collect data for my research. Looking forward to a favorable response.

Yours Sincerely.

Dr. Teofilo Cordova Pumacahua
CMP 41600, Reg. H58/71030/2011
University of Nairobi-Kenya
Tel: 0051 (84) 501850 (Cusco)

Appendix 7: Ophthalmic prescription

San Juan De Dios Hospital of Cusco, Ophthalmology service.

School screening study project in Cusco by Dr. Teofilo Cordova Pumacahua of the University of Nairobi with cooperation of ophthalmology clinic of San Juan de Dios Hospital Cusco, Peru.

Dear parent.

Please note that your child …….. Who had an eye examination today was found to have a refractive error and he/she is hereby prescribed the following spectacles:

Eye	Spherical	Cylindrical	Axis
RE			
LE			

DIP: …….

Dr. Teofilo Cordova

CMP 41600

Date: ……..

Appendix 8: Patient referral form

Dear parent.

Please note that your child ……
Who had an eye examination today was found to have ……
please Kindly bring him/her to the eye clinic at San Juan de Dios Hospital of Cusco for management.

Dr. Teofilo Cordova Pumacahua.

Date: ……..

Appendix 9: WHO categories of visual impairment and blindness.[40]

Presenting distance Visual Acuity with BCVA in the better eye		
Category	**Worse than**	**Equal to or better than**
0 Mild or no Visual impairment (Normal Vision)		**6/18**
1 Moderate visual impairment	**6/18**	**6/60**
2 Severe visual impairment	**6/60**	**3/60**
3 Blindness	**3/60**	**1/60**
4 Blindness	**1/60**	**Light perception**
5 Blindness	**No light perception**	
9	**Undetermined or unspecified**	

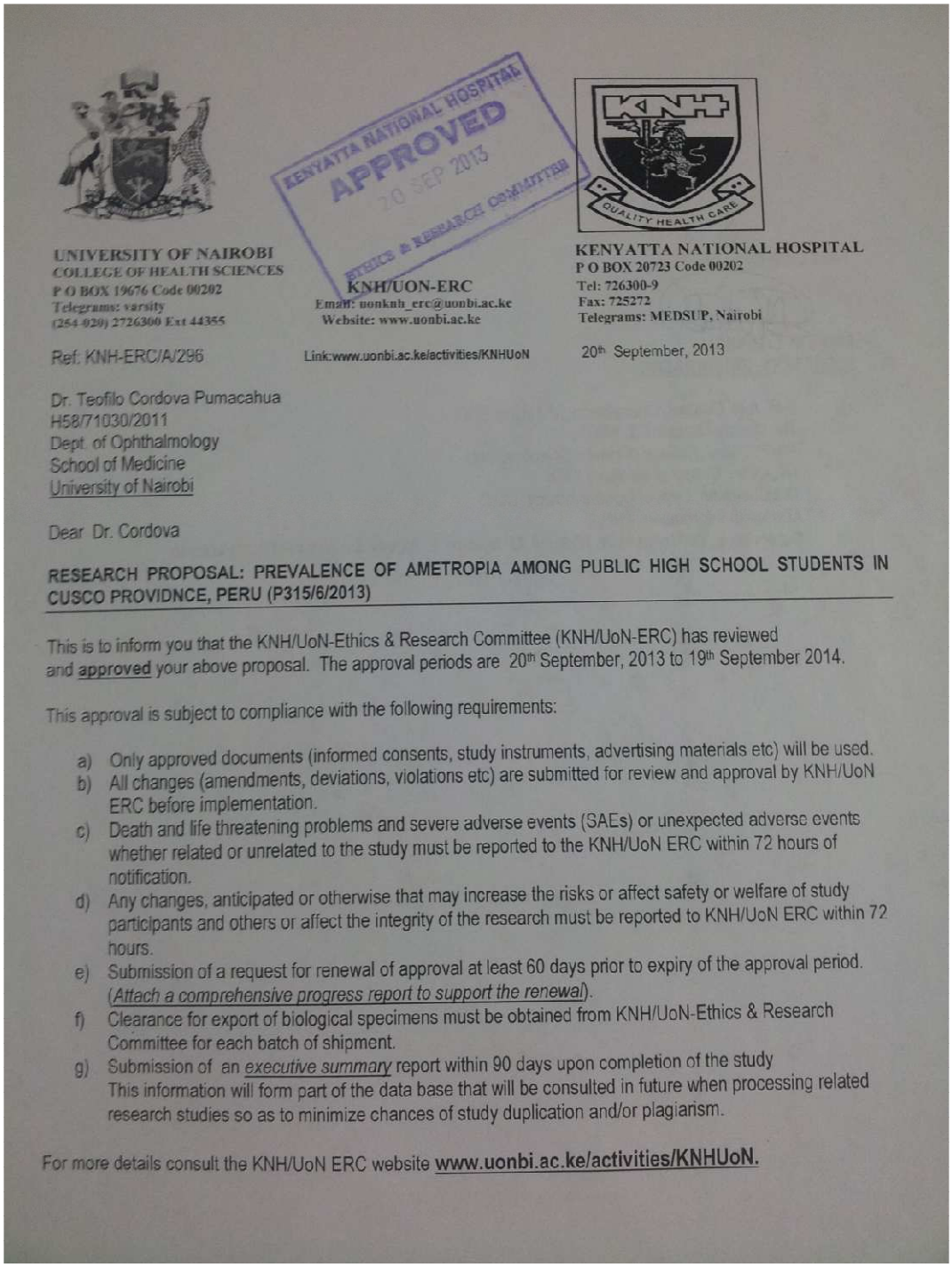
Appendix 10: List of public schools in Cusco province, Peru. Selected schools marked (*)

#	Code module	Name of school	Department / Province / District
1	0782664	50002 LUIS VALLEJOS SANTONI	Cusco / Cusco / Cusco
2	1386234	50025	Cusco / Cusco / Wanchaq
3	0785097	50048 LOS INCAS	Cusco / Cusco / Cusco
4	1386226	50723 CECILIA TUPAC AMARU *	Cusco / Cusco / Santiago
5	1522721	50731 NUESTR SEÑORA DE LA NATIVIDAD DE PROGRESO *	Cusco / Cusco / Wanchaq
6	1370345	51003	Cusco / Cusco / Cusco
7	1322593	51004 SAN VICENTE DE PAUL	Cusco / Cusco / Cusco
8	1370378	51006 TUPAC AMARU	Cusco / Cusco / Santiago
9	0735035	51014 ROMERITOS	Cusco / Cusco / Wanchaq
10	0579151	51015 SAN FRANCISCO DE BORJA	Cusco / Cusco / Cusco
11	1386432	51023 SAN LUIS GONZAGA	Cusco / Cusco / San Jeronimo
12	1370360	51045	Cusco / Cusco / Wanchaq
13	0233130	ALEJANDRO VELASCO ASTETE	Cusco / Cusco / San Jeronimo
14	0621300	ANTONIO RAYMONDI	Cusco / Cusco / Saylla
15	0591198	ARTURO PALOMINO RODRIGUEZ	Cusco / Cusco / Wanchaq
16	1352269	BOLIVARIANO	Cusco / Cusco / San Sebastian
17	1379544	CCORCA	Cusco / Cusco / Ccorca
18	1201789	CENTRO JUVENIL MARCAVALLE	Cusco / Cusco / Wanchaq
19	0236117	CIENCIAS*	Cusco / Cusco / Cusco
20	0236109	CLORINDA MATTO DE TURNER	Cusco / Cusco / Cusco
21	0207449	COMERCIO 41	Cusco / Cusco / Cusco
22	0517698	CORONEL FRANCISCO BOLOGNESI	Cusco / Cusco / Santiago

23	0236414	DIEGO QUISPE TITO*	Cusco / Cusco / San Sebastian
24	0236224	EDUCANDAS*	Cusco / Cusco / Cusco
25	0236778	FE Y ALEGRIA 20	Cusco / Cusco / Santiago
26	0236364	FORTUNATO L HERRERA	Cusco / Cusco / Cusco
27	0927814	GRAN MARISCAL ANDRES AVELINO CACERES	Cusco / Cusco / Santiago
28	0236349	HUMBERTO LUNA	Cusco / Cusco / Cusco
29	0233056	INCA GARCILASO DE LA VEGA	Cusco / Cusco / Cusco
30	0616185	INCA RIPAQ	Cusco / Cusco / San Sebastian
31	1061449	JORGE CHAVEZ CHAPARRO	Cusco / Cusco / Cusco
32	1386127	JOSE ABELARDO QUIÑONES	Cusco / Cusco / Wanchaq
33	0730481	MANUEL SEOANE CORRALES	Cusco / Cusco / Poroy
34	0579177	MARIA DE LA MERCED	Cusco / Cusco / Wanchaq
35	0591131	MIGUEL GRAU SEMINARIO	Cusco / Cusco / Wanchaq
36	1386168	NUESTRA SEÑORA DE FATIMA	Cusco / Cusco / Wanchaq
37	0236786	NUESTRA SEÑORA DEL ROSARIO FE Y ALEGRIA 21	Cusco / Cusco / San Jeronimo
38	0928200	OLIMPICO PERUANO	Cusco / Cusco / Wanchaq
39	1390137	PACHAKUTEQ INKA YUPANKI	Cusco / Cusco / Santiago
40	0782680	REVOLUCIONARIA SANTA ROSA	Cusco / Cusco / San Sebastian
41	0933598	SAGRADO CORAZON DE JESUS	Cusco / Cusco / Wanchaq
42	0236232	SANTA ROSA	Cusco / Cusco / Cusco
43	0489096	SIMON BOLIVAR	Cusco / Cusco / Cusco
44	0236174	URIEL GARCIA	Cusco / Cusco / Wanchaq
45	0730515	VICTOR RAUL HAYA DE LA TORRE	Cusco / Cusco / San Sebastian
46	0927848	VIRGEN DE FATIMA	Cusco / Cusco / San Sebastian
47	0591164	VIVA EL PERU	Cusco / Cusco / Santiago

Appendix 11: Ethical approval letters

A. Approval letter from KNH/UoN ethical research committee.



KENYATTA NATIONAL HOSPITAL
APPROVED
20 SEP 2013
ETHICS & RESEARCH COMMITTEE

UNIVERSITY OF NAIROBI
COLLEGE OF HEALTH SCIENCES
P O BOX 19676 Code 00202
Telegrams: varsity
(254-020) 2726300 Ext 44355

KNH/UON-ERC
Email: uonknh_erc@uonbi.ac.ke
Website: www.uonbi.ac.ke
Link:www.uonbi.ac.ke/activities/KNHUoN

KENYATTA NATIONAL HOSPITAL
P O BOX 20723 Code 00202
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP, Nairobi

Ref: KNH-ERC/A/296

20th September, 2013

Dr. Teofilo Cordova Pumacahua
H58/71030/2011
Dept. of Ophthalmology
School of Medicine
University of Nairobi

Dear Dr. Cordova

RESEARCH PROPOSAL: PREVALENCE OF AMETROPIA AMONG PUBLIC HIGH SCHOOL STUDENTS IN CUSCO PROVIDNCE, PERU (P315/6/2013)

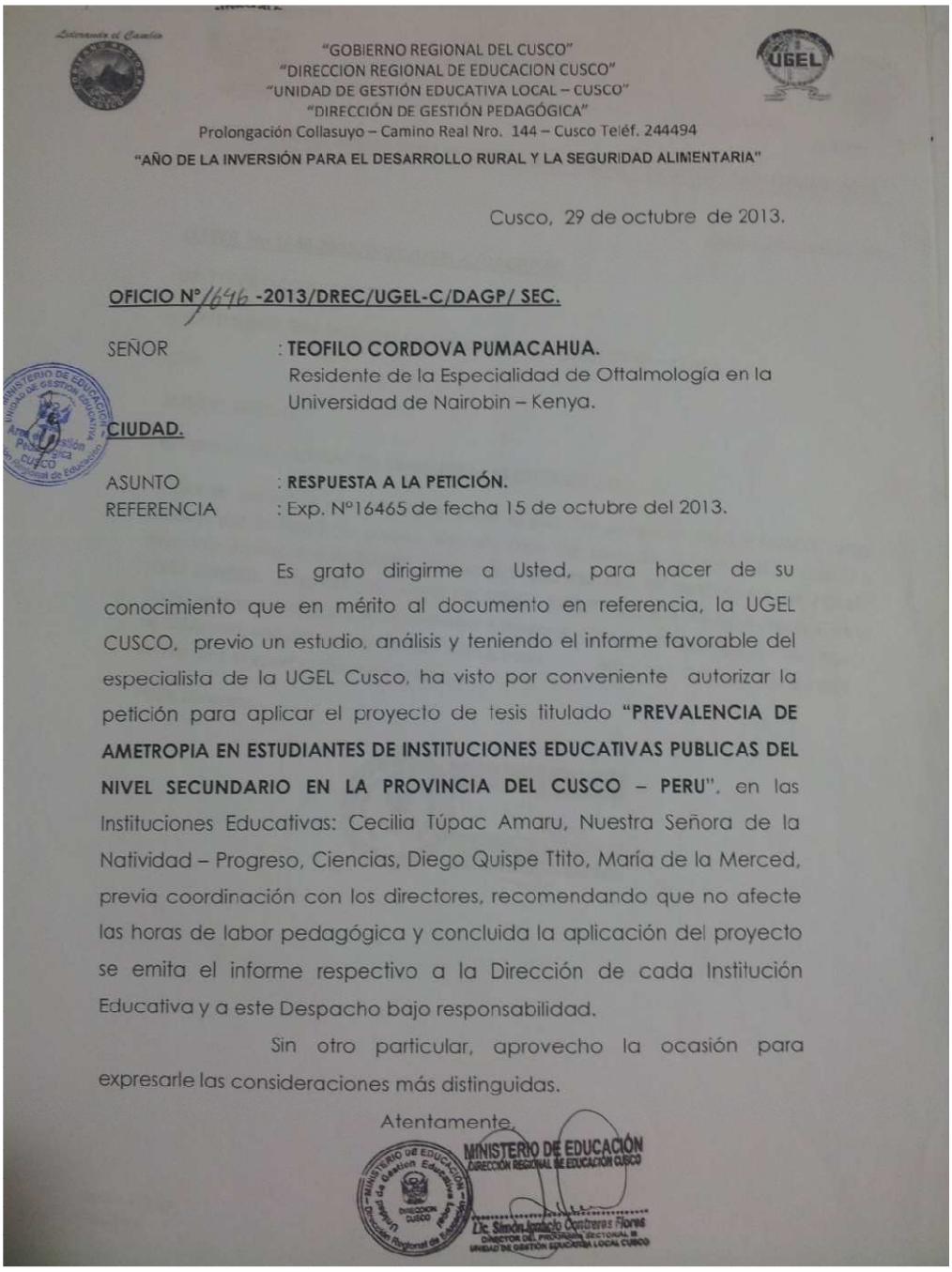
This is to inform you that the KNH/UoN-Ethics & Research Committee (KNH/UoN-ERC) has reviewed and **approved** your above proposal. The approval periods are 20th September, 2013 to 19th September 2014.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by KNH/UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH/UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH/UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH/UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

For more details consult the KNH/UoN ERC website **www.uonbi.ac.ke/activities/KNHUoN.**

B. Approval letter from Ministry of Education Cusco – Peru Spanish version.



"GOBIERNO REGIONAL DEL CUSCO"
"DIRECCION REGIONAL DE EDUCACION CUSCO"
"UNIDAD DE GESTIÓN EDUCATIVA LOCAL – CUSCO"
"DIRECCIÓN DE GESTIÓN PEDAGÓGICA"
Prolongación Collasuyo – Camino Real Nro. 144 – Cusco Teléf. 244494

"AÑO DE LA INVERSIÓN PARA EL DESARROLLO RURAL Y LA SEGURIDAD ALIMENTARIA"

Cusco, 29 de octubre de 2013.

OFICIO N° 1646 -2013/DREC/UGEL-C/DAGP/ SEC.

SEÑOR : **TEOFILO CORDOVA PUMACAHUA.**
Residente de la Especialidad de Oftalmología en la Universidad de Nairobin – Kenya.

CIUDAD.

ASUNTO : **RESPUESTA A LA PETICIÓN.**
REFERENCIA : Exp. N°16465 de fecha 15 de octubre del 2013.

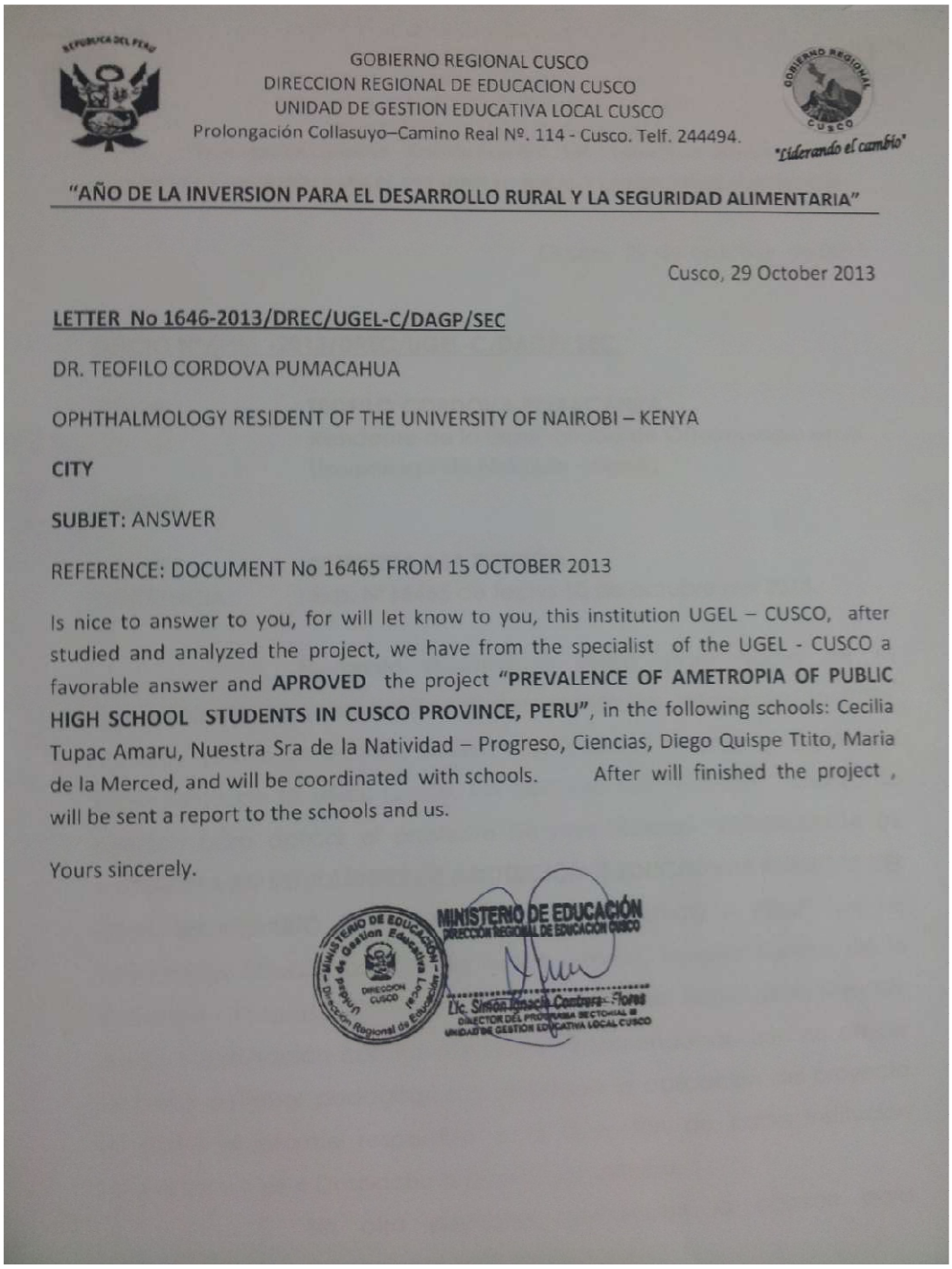
Es grato dirigirme a Usted, para hacer de su conocimiento que en mérito al documento en referencia, la UGEL CUSCO, previo un estudio, análisis y teniendo el informe favorable del especialista de la UGEL Cusco, ha visto por conveniente autorizar la petición para aplicar el proyecto de tesis titulado **"PREVALENCIA DE AMETROPIA EN ESTUDIANTES DE INSTITUCIONES EDUCATIVAS PUBLICAS DEL NIVEL SECUNDARIO EN LA PROVINCIA DEL CUSCO – PERU"**, en las Instituciones Educativas: Cecilia Túpac Amaru, Nuestra Señora de la Natividad – Progreso, Ciencias, Diego Quispe Ttito, María de la Merced, previa coordinación con los directores, recomendando que no afecte las horas de labor pedagógica y concluida la aplicación del proyecto se emita el informe respectivo a la Dirección de cada Institución Educativa y a este Despacho bajo responsabilidad.

Sin otro particular, aprovecho la ocasión para expresarle las consideraciones más distinguidas.

Atentamente,

MINISTERIO DE EDUCACIÓN
DIRECCIÓN REGIONAL DE EDUCACIÓN CUSCO
Lic. Simón Ignacio Contreras Flores
DIRECTOR DEL PROGRAMA SECTORIAL III
UNIDAD DE GESTIÓN EDUCATIVA LOCAL CUSCO

C. Approval letter from Ministry of Education Cusco - Peru, English version.



GOBIERNO REGIONAL CUSCO
DIRECCION REGIONAL DE EDUCACION CUSCO
UNIDAD DE GESTION EDUCATIVA LOCAL CUSCO
Prolongación Collasuyo–Camino Real Nº. 114 - Cusco. Telf. 244494.

"Liderando el cambio"

"AÑO DE LA INVERSION PARA EL DESARROLLO RURAL Y LA SEGURIDAD ALIMENTARIA"

Cusco, 29 October 2013

LETTER No 1646-2013/DREC/UGEL-C/DAGP/SEC

DR. TEOFILO CORDOVA PUMACAHUA

OPHTHALMOLOGY RESIDENT OF THE UNIVERSITY OF NAIROBI – KENYA

CITY

SUBJET: ANSWER

REFERENCE: DOCUMENT No 16465 FROM 15 OCTOBER 2013

Is nice to answer to you, for will let know to you, this institution UGEL – CUSCO, after studied and analyzed the project, we have from the specialist of the UGEL - CUSCO a favorable answer and **APROVED** the project **"PREVALENCE OF AMETROPIA OF PUBLIC HIGH SCHOOL STUDENTS IN CUSCO PROVINCE, PERU"**, in the following schools: Cecilia Tupac Amaru, Nuestra Sra de la Natividad – Progreso, Ciencias, Diego Quispe Ttito, Maria de la Merced, and will be coordinated with schools. After will finished the project , will be sent a report to the schools and us.

Yours sincerely.

MINISTERIO DE EDUCACIÓN
DIRECCIÓN REGIONAL DE EDUCACIÓN CUSCO
Lic. Simón Tesch Contreras Flores
DIRECTOR DEL PROGRAMA SECTORIAL III
UNIDAD DE GESTIÓN EDUCATIVA LOCAL CUSCO

Appendix 12: Photos

Photo 1: Students at girls' school going to screening process.

Photo 2: Visual Acuity screening processes.

Photo 3: Objective refraction processes.

Photo 4: Subjective refraction processes.