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The prevalence of refractive error in three communities of Cape Town, South Africa

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Abstract

The prevalence, distribution and demographic associations of refractive error in three communities in Cape Town, South Africa were assessed. In this cross-sectional study, a clustered random sampling procedure was used to recruit participants (*n*=176; age=40.6±14.7 years; males=76, females=96) from Khayelitsha, Milnerton, and Mitchell's Plain. From March to May 2010, participants underwent autorefraction and subjective refraction eye examinations. A structured interview was used to collect data on socio-demographics, age, gender, level of education, employment and race. Participants younger than 15 years, non-residents, or residents for less than six months, who declined signing the informed consent forms were excluded from the study. In this study myopia was defined as the spherical equivalent value in the better eye of −1.00D or worse and hyperopia as the spherical equivalent value in the better eye of ≥1.00D. Astigmatism was defined as −0.50 cylinder or worse in the better eye.

The prevalence of myopia was 17.4% with a 90% confidence interval (CI) of 12.65-22.15, hyperopia was 13.4% (90% CI 9.13-17.67), and astigmatism was 60% (90% CI 53.86-66.14). Myopia was found to be significantly associated with race and age; while hyperopia was significantly associated with age, employment and race. The results of this study may assist in planning for eye care on district level. (*S Afr Optom* 2012 **71**(1) 32-38)

Key Words: Astigmatism, cross sectional study: refraction, prevalence of refractive error

Introduction

A refractive error may be defined as a state in which the optical system of the non-accommodating eye fails to bring parallel rays of light to focus on the fovea. It is caused by an incongruity between the axial length of the eye and the powers of the optical elements of the eye, so that compensatory lenses or other refractive treatment are required to produce a clear image[1].

Refractive error[2] was the main ocular problem presented at a rural, South African eye clinic, thereby swelling the volume of patients at the clinic. In the United States 80% of the visual impairment in persons 12 years and older is due to refractive error[3]. A systematic review on the prevalence of refractive er-

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ror in Western Europe, United States and Australia showed that the prevalence of myopia is about 24% in the United States, about 27% in Western Europe and about 16% in Australia. For hyperopia[4] the prevalence was 10%, 12% and 6% respectively. In a similar study, in a South Indian population, Raju *et al* reported the prevalence of myopia to be almost 27% and hyperopia to be about 19%[5]. Bekibele *et al* found in Ibadan, Nigeria, the prevalence of refractive error, to be approximately 17%[6].

To eradicate poor vision due to uncorrected refractive error, the World Health Organisation (WHO) launched the 'Vision 2020: The Right to Sight' initiative[7] in 2000. In South Africa, the availability of refractive services in the public sector is limited[8] and this poor distribution of eye care professionals has resulted in most of the indigent population finding refractive services inaccessible or unaffordable[9]. Furthermore, substantial expense is involved in providing eye care services to persons needing refractive compensation. Although not adequately evaluated in Cape Town or in South Africa, the direct annual cost of refractive correction for distance visual impairment is estimated to be $5.5 billion in the United States of America for persons 40 years and older[10]. The high prevalence of refractive error and substantial costs of refractive correction make these conditions important public health and economic problems in many parts of the world.

In South Africa the extent of refractive error has not been adequately evaluated. However a few studies have been done in children[8] and drivers[11]. This study is motivated by the paucity of refractive error data to guide the efficient mobilization of refractive and eye care services in South Africa. Refractive errors and the associated demographics in the three communities of Cape Town, namely; Khayelitsha, Milnerton, and Mitchell's Plain will be described in this study.

Methodology

This study commenced after approval by the Stellenbosch University Ethics Committee and was conducted in accordance with the Declaration of Helsinki. The study was conducted in Khayelitsha, Mitchell's Plain and Milnerton in the Cape Town metropolitan area, Western Cape. These regions represent three diverse demographic and socio-economic communities. The cluster sampling method was used to select the study population using the enumerator areas (EA) created during the 2001 census. Expert services from the Western Cape Department of Statistics were employed to map the EA boundaries using a hand held device to access the global positioning system (GPS) coordinates. Five EAs and 10 households from each EA were randomly selected. All occupants of eligible households who were 15 years or older, had lived in Cape Town for 6 months or more and were willing to sign the consent form were enrolled.

Participant enrolment

The principal investigator (MO) approached the occupants of the selected households accompanied by assisting police sector managers. The occupants were informed of the study and appointments for enumerator visits obtained; participants were expected to be at home on Saturdays and Sundays. The enumerators were trained to give verbal explanations on the nature, possible risks and benefits of the study. They also ensured that every participant signed the consent form. After enrolment, the participants were referred to the study centre in their community for a free eye examination. Each community had a study centre. The enumerators arranged participant appointments according to the schedule previously agreed upon with the optometrists. Eye examinations were done at the Milnerton centre by Colin Philip while the Khayelitsha and Mitchell's Plain centres were done by Godwin Ijieh. The two optometrists each, have over twenty years' experience in eye examinations.

Eye Examinations

Eye examinations were performed by optometrists at the study centres. The entry distance visual acuity was measured with the Snellen distance visual acuity chart at 6 metres, while the entry near visual acuity was taken with the Vocational reading chart at 40 cm. Objective refraction was done with the autorefractor (Grand Seiko, model KR8800, Japan). Autorefraction readings were used as the starting point, and refinement of sphere, cylinder, and axis was done until the best visual acuity was obtained. Visual acuity with best correction was done with the Snellen distance chart and the Vocational reading chart. All the centres had the same instruments. All the participants underwent these tests. The optometrists completed a

participant data sheet containing information on: entry visual acuity at distance and near, best correction, visual acuity with best correction, reasons for referring any participant and general comments.

Definitions

Myopia and hyperopia were determined from the refractive error results, from the eye with the lower absolute spherical equivalent (SE) value. Astigmatism was recorded in minus cylinder notation. The SE value of an eye was computed as the spherical value plus half the cylindrical value. Myopia was significant if it had SE value of −1 D or worse; and hyperopia 1 D or greater. Astigmatism was defined as a cylinder of −0.50 or worse in the better eye irrespective of the axis. The authors acknowledge that defining and analysing the data according to the 3-D dioptric power space model developed by Harris12 would mathematically have been superior, but elected to use the clinical SE concept as this is more widely used by optometrists in clinical practice. Comparison with previous studies would also be less complex. The demographic associations of refractive error, that is, age, gender, race, education and employment were assessed.

Data Management and Analysis

The data sheets were reviewed for accuracy and completeness of information on collection. Any missing data was corrected; the participants with missing data were invited for re-examination. The subjective refractive data was analysed using *Statistica*. The better eye was chosen for analysis and individuals were categorised based on vision in the better eye.

Descriptive statistics reported means, standard deviations, ranges, proportions and their 90% CI. In the analysis, 90% CI was used to accommodate a sample size concomitant with budget and time constraints. Comparisons of proportions of prevalence of myopia, hyperopia and astigmatism in the population were ascertained using the chi-square test. The comparisons of mean participant ages and the ages of those with myopia, hyperopia, and astigmatism were performed using *t*-tests. Independent risk factors for myopia, hyperopia and astigmatism were assessed by performing logistic regression analyses. The explanatory variables built in and adjusted for in the model were: age, gender, race, education and employment. A 5% level of significance was used for all statistical analysis.

Results

A total of 176 participants were enrolled for this study, four were excluded from the analysis because they declined to have the eye examination. Study participants' ages ranged from 16 to 74. Their age groups were evenly distributed, however 20-25 year-olds accounted for the largest group. The participants comprised 76 (44%) males and 96 (56%) females. There was no significant difference in proportion between male participation and female participation (p=0.15). The race distribution included 76 (44%) blacks; 38 (22%) whites; and 58 (34%) coloureds. A total of 53 (31%) had a maximum of primary school education; 87 (51%) secondary school education; and 32 (19%) tertiary education. A total of 120 (70%) were employed; 31(18%) unemployed; and 21 (12%) were on a government grant.

Myopia

Thirty (17.4%, 90% CI 12.65-22.15) of the study population had myopia; the mean age among myopes was 35.4±12.19 years, lower than the mean age of the study population (40.6 ±14.7 years). Twelve (16%) males and 18 (19%) females had myopia. Although there was no significant difference in the presence of myopia in both sexes (p=0.61), the prevalence of myopia was higher in females. The prevalence estimates for myopia age 15 - 30 and 31 - 45 was the same in males, and showed a slight increase in females. There was however, a decline in the prevalence of myopia after age 45 in both sexes. Females had higher prevalence of myopia than males, except at age 46 to 60, where the prevalence in males was higher (Figure1).

The prevalence of myopia increased with the level of education. Six (11%) of the 53 participants with a maximum of primary school education had myopia; 17 (20%) of the 87 with secondary school education had myopia; and 7 (22%) of the 32 with tertiary education had myopia. Though this increase was not statistically significant (p= 0.35).The prevalence of myopia was higher in the employed. Five (16%) of the 31 unemployed had myopia; 23 (19%) of the 120 employed had myopia; and two (10%) of the 21 on a government grant had myopia. This difference, how-

ever, was not statistically significant. (p=0.55).

The prevalence of myopia showed a significant relationship with race, p=0.036 (Figure 2). Seven (9%) of 76 blacks had myopia; 10 (26%) of the 38 whites had myopia; and 13 (22%) of the 58 coloureds had myopia.

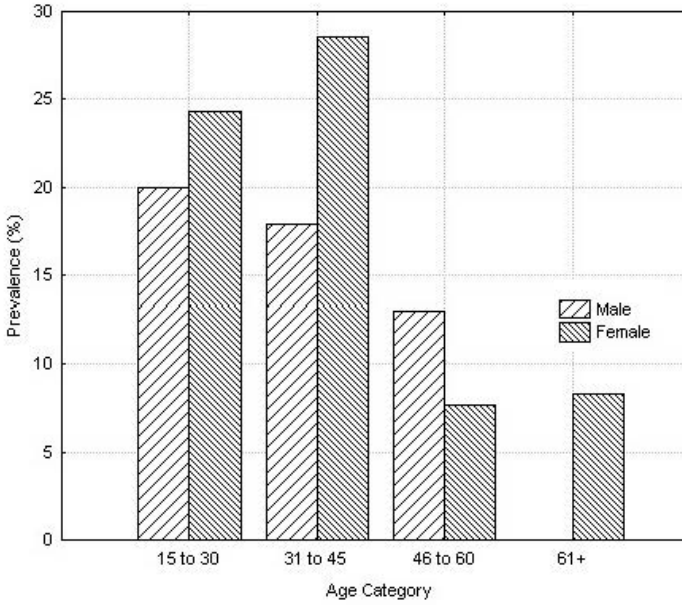

Figure 1 Age adjusted prevalence of myopia by gender

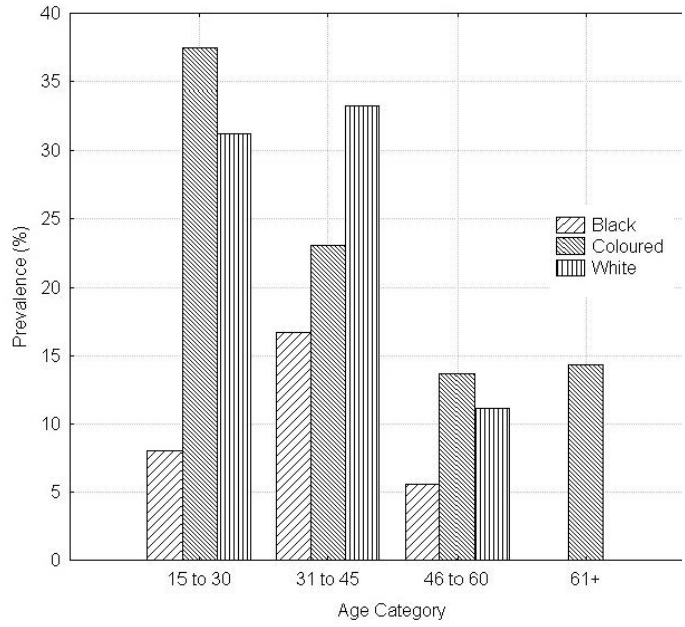

Figure 2 Histogram of myopia by age and race

Hyperopia

Twenty three (13.4%), (90% CI 9.13-17.67), of the study population had hyperopia. The mean age among hyperopes was 47.39±15.22 years. This was significantly higher than the age of the study population (p=0.008). Seven (9%) males and 16 (17%) females had hyperopia. The prevalence of hyperopia was higher in females than in males, except at age 15-30 were it was higher in males. This however was not statistically significant, p=0.15 (Figure 3).

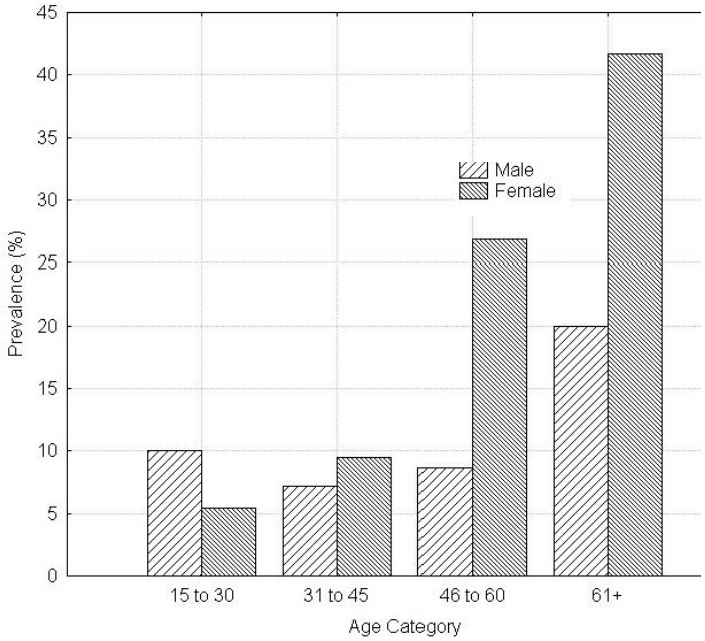

Figure 3 Age adjusted prevalence of hyperopia by gender

Nine (17%) of the 53 with a maximum of primary school education had hyperopia; nine (10%) of the 87 with a secondary school education had hyperopia; and five (16%) of the 32 with a tertiary education had hyperopia. Hyperopia showed no significant relationship with education (p= 0.49). Six (19%) of the 31 unemployed had hyperopia; ten (8%) of the 120 employed had hyperopia; seven (33%) of the 21 on government grants had hyperopia. Hyperopia had significant relationship with employment status (p=0.001). Six (8%) of the 76 blacks had hyperopia; ten (26%) of the 38 whites had hyperopia; and seven (12%) of the 58 coloureds had hyperopia. Hyperopia showed a significant relationship with race, p= 0.003 (Figure 4).

Astigmatism

A total of 103 (60%) of the study population had astigmatism. This prevalence included those with only astigmatism and those with myopia or hyperopia concurrent with astigmatism. The mean age among those with astigmatism was 40.14±13.22 years. This was not significantly different from the study population (p=0.08). A total of 47 (62%) of males and 56

(58%) of females had astigmatism. There was no significant difference in the presence of astigmatism in both sexes (p=0.096). Thirty (60%) out of the 53 with a maximum of primary school education had astigmatism; twenty-two (25%) of the 87 with a secondary school education had astigmatism; and twenty-two (69%) of the 32 with a tertiary education had astigmatism. Astigmatism showed no significant association with levels of education (p=0.93).Eighteen (58%) of the 31 unemployed had astigmatism; seventy-four (62%) of the 120 employed had astigmatism; and ten (48%) of the 21 on government grants had astigmatism. Astigmatism had no significant relationship with employment (p=0.62). Forty-seven (62%) of the 76 blacks had astigmatism; twenty (53%) of the 38 whites had astigmatism; and twenty-nine (50%) of the 58 coloureds had astigmatism. Astigmatism had no significant relationship with race (p= 0.25).

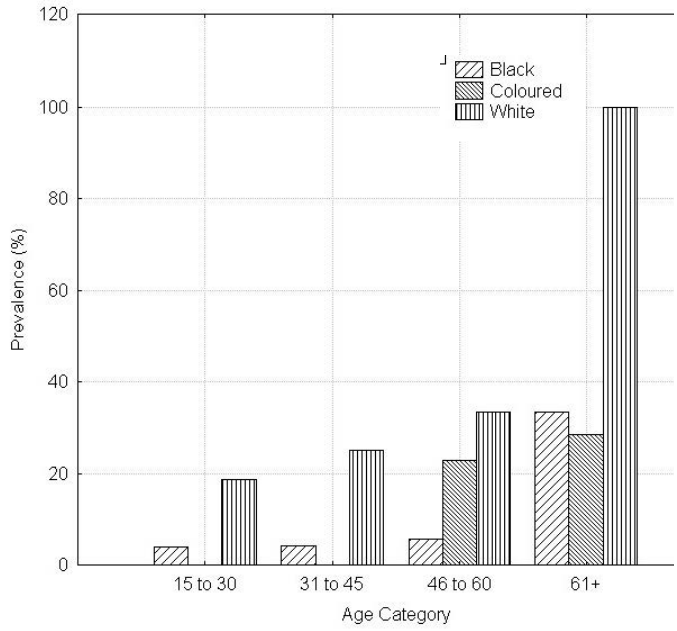

Figure 4 Histogram of hyperopia distribution by race

Discussion

In this study refractive error was found to be common in these three communities among those 15 years and older. The prevalence of myopia in this study was 17.4% (90% CI 12.65-22.15), similar to that reported by Dandona *et al*, in India (19.39% and 95% CI 16.54-22.24)[13], and to that reported by Attebo *et al*, in an Australian population (15%)[14]. However, Vitale *et al*[3], in a study in the United States, in people 20 years and older reported myopia prevalence to be 33.1% (95% CI, 31.5%-34.7%). This is higher than the findings in this study and suggests that the prevalence of myopia in Cape Town may be similar to that of the Indian and Australian population but may be lower than that of the United States. This study found a decrease in myopia with an increase in age. This is in contrast to the study by Dandona *et al* which reported an increase in myopia with increased age[13]. A recent study has shown however, that an increase in myopia with increased age reported in earlier studies was due to nuclear sclerosis[6]. Few studies have reported a decrease in myopia with age[3, 14, 15]. This may be due to intrinsic, age-related changes in the refractive components of the eye[16]. The prevalence of myopia was higher in females (19%), than in males (16%). This has been reported in previous studies[3, 15, 16]. This study showed a relationship between race and myopia. Myopia was more common among whites (26%) and the least common among blacks (9%) in the study communities. Previous studies have shown that myopia is associated with race[3, 14].

The prevalence of myopia increased with education and was also higher in the employed. However, in our study this was not significant in the logistic regression analysis. Educational status has been shown to be closely related to near work and association between near work and myopia has been reported previously[14, 17, 18]. This may be due to near work being more comfortable for myopes or near work being the cause of myopia.

The prevalence of hyperopia in this study was 13.4% (90% CI 9.13-17.67). This finding is similar to Dandona *et al* in an urban population in Southern India (9.83%)[13]; and Liang *et al* reported a 15.9% occurrences in a rural Chinese adult population19. Vitale *et al* reported a prevalence of 3.6% in the United States[3]; and Attebo *et al* reported a prevalence of 57% in the Blue Mountains, Western Australia[14]. It is important to note that this wide variation is primarily due to the variations in hyperopia definitions in the various studies. Vitale *et al* defined hyperopia as an SE value of ≥3D, while Attebo defined hyperopia as an SE value of ≥0.50. In our study, hyperopia was found to be significantly associated with age in the logistic regression analysis. This is similar to reports of earlier studies[5, 14]. The increase in hyperopia with age may be due to a loss of residual accommodation or a

decrease in the power of the ageing lens. This study found a higher prevalence of hyperopia in females than in males; a finding similar to other studies[14, 20, 21]. This may be because female's eyes on average have a shorter axial length and shallower anterior chamber depth than those of males, and hence a higher probability of being hyperopic[22]. This factor however was not significant in our logistic regression analysis. Hyperopia was found to be significantly associated with race and employment in the logistic regression analysis. Hyperopia was more common among whites and the least common among blacks in the study communities. The prevalence of astigmatism in this study was 60%, (90% CI 53.86-66.14). This however has been built into the values of myopia and hyperopia since the SE method was used in the definitions and the analysis. Vitale *et al* found prevalence of astigmatism to be 36.2% in the United States study population[3]; Dandona *et al* found 12.94% in India[13] while Liang found 24.5% in a rural Chinese adult population[19]. Thus, there is a wide variation in the prevalence of astigmatism among the studies. This wide variation is primarily due to the variations in astigmatism definitions in the various studies. Vitale *et al* defined astigmatism as a cylinder of 1.0 or more in the eye with higher astigmatism, while Dandona and Liang, excluded participants who were wearing corrective spectacles and analysed results of the right eyes only. Astigmatism was found not to be associated with age; level of education; race; nor gender.

One of the strengths of our study is that all the participants had the same eye examinations. Also, almost all eligible participants meeting the inclusion criteria participated because the sampling method and the police assistance made it possible for the study to be successfully completed. One limitation of this study however was the small sample size (N=172 eye). With a larger sample size, the trends may have provided more statistically significant results. Also, the impact of occupation, especially near vision tasks on refraction was not assessed. Other limitation includes the use of the SE method to analyse the data instead of the 3D dioptric power space method.

Conclusion

Refractive error was present in 30.8% of the study population. Myopia was found to decrease with increased age, while hyperopia was found to increase with increased age. Myopia and hyperopia were more common in females than in males. Myopia was associated with race and age, while hyperopia was associated with age, employment and race.

The three communities had a 2009 midyear population of 809 023 inhabitants 15 years and older, while the Cape Town metropolitan area had a 2009 midyear population of 2 600 000 inhabitants 15 years and older[23]. This suggests that a total of 800 800 (90% CI 650 000 to 950 000) persons, age 15 years and older, in the municipality may have refractive error; 452 400 (90% CI 329 000 to 576 000) may be myopic, while 348 400 (90% CI 237 000 to 459 000) may be hyperopic.

The Western Cape Province has a population of 3 900 000 persons, 15 years and older[23]. This translates into a total of 1 200 000 (90% CI 975 000 to 1 430 000) persons age 15 years and older, who may have refractive error; and 678 600 (90% CI 493 000 to 864 000), who may be myopic; while 522 600 (90% CI 356 000 to 689 000) may be hyperopic.

Data about the prevalence, distribution and demographic associations of refractive error reported in this study may help in planning for effective eye care services in the Cape Town metropolitan area and Western Cape to reduce the visual impairment due to refractive error.

Recommendations

1. A high powered, large sample size, population-based study should be implemented in the Western Cape to confirm the results of this study.
2. Assessing the impact of occupation, especially near vision tasks, on refraction should form part of the above extended study.
3. The study findings could be used to design a social programme for the indigent population, whereby affordable access to spectacles becomes a reality.

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Disclosure

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