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Five-year visual outcome among people with correctable visual impairment: the Liwan Eye Study

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ABSTRACT

Importance: Longitudinal data on visual outcome of correctable visual impairments (VI) are of paramount importance for decision-maker to estimate burden and demand to treat avoidable VI.

Background: To assess the 5-year visual outcome among participants with correctable VI and to identify associated risk factors.

Design: Population-based longitudinal cohort study.

Participants: Participants with correctable VI at baseline attended the 5-year follow-up visit of the Liwan Eye Study.

Methods: Presenting visual acuity (PVA) with habitual refractive correction was assessed using an Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Then participants with PVA<20/40 in either eye underwent further non-cycloplegic subjective refraction to obtain their best-corrected visual acuity. Correctable VI was defined as having a PVA of <20/40 in the better eye which could be improved to $\geq 20/40$ after refractive correction.

Main outcome measures: 5-year visual outcome among participants with correctable VI.

Results: Among 1405 participants at baseline examination, 188 (13.4%) had correctable VI, of whom 118(62.8%) were re-examined at the 5- year follow-up, including 39(33.9%) who progressed to non-correctable VI, 43(37.4%) who had persistent correctable VI, and 33(28.7%) who were converted to normal vision. In multivariate logistic regression, compared to participants who were no longer visual impaired, significant risk factors for participants with persistent VI were older, had income<1000RMB/month, and more myopia spherical equivalent.

Conclusions: Over 2/3 participants with correctable VI remained to have VI after 5 years, among whom 50% are correctable by spectacles, highlighting the need to improve the refractive care accessibility to treat avoidable VI in China.

Key words: Correctable visual impairment, non-correctable visual impairment, longitudinal cohort study

INTRODUCTION

According to World Health Organization estimation, there were 39 million people living with blindness and 246 million people with low vision worldwide,¹ and these numbers are likely to increase in the aging society. Visual impairment (VI) hampers daily activities and quality of life, especially for elderly people.²⁻⁴ Previous population-based studies have reported uncorrected refractive error as the major cause of VI among older population, with 22% ~71.4% of which can be easily corrected by spectacles or surgeries.⁵⁻⁷ It has been suggested that providing appropriate correction for refractive errors is a cost-effective intervention with huge functional improvement.⁸ The "Vision 2020 -The Right to Sight" initiative has included refractive errors correction as an essential part of the strategy for the elimination of avoidable VI and blindness.⁹

Previous studies on correctable VI were mostly cross-sectional in design, and little was known about the progression of correctable VI. Population-based longitudinal data on visual outcome among people with correctable VI are of paramount importance for decision-maker to estimate the burden and demand to treat avoidable VI. The purpose of this study was to assess the outcome of correctable VI over a 5-year period, as well as its associated risk factors, among older adults in urban southern China.

METHODS

Detailed methodology of the current study had been reported elsewhere.¹⁰ In brief, the Liwan Eye Study was a population-based study initiated in 2003, and all baseline participants were invited to participate in the 5-year follow up examination. Overall, 1405 of 1864 eligible subjects (age range: 50~93 years, mean age: 65.3 years)

attended the baseline eye examinations in 2003 (participant rate of 75.4%). At the 5-year follow up examination in 2009, 924 of 1232 survivors (baseline age range: 50~89 years. mean age: 63.4 years) attended (response rate of 75%). Ethical approval was obtained from the Zhongshan Ophthalmic Center Ethics Review Board and the Research Governance Committee of Moorfields Eye Hospital in London, England. The study was conducted in accordance with the tenets of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from all subjects.

All baseline and follow-up examinations were conducted under the same protocol. Presenting visual acuity (PVA) was measured with an Early Treatment Diabetic Retinopathy Study (ETDRS) visual chart with habitual refractive correction by an experienced optometrist. Measurement of VA began at the top line (20/200) with a distance of 4 meters. If the participant correctly read at least 4 of the 5 optotypes, the testing continued to line 5 (20/100), line 7 (20/50), line 10 (20/25), and line 11 (20/20). If the participant was unable to read 4 of the 5 optotypes at any one level, the line above the failed line was tested, until the participant successfully read all the optotypes. If the participant could not recognize the optotypes of the top line at 4 meters, the participant was asked to move to 2 meters and then to 1 meter, progressing down the chart as described earlier. The lowest line recognized successfully was recorded as the PVA for the eye. Finger counting (FC), hand motions (HM), light perception (LP), or no light perception (NLP) was further assessed for participants with PVA < 20/ 400. Participants with a PVA of <20/40 in either eye underwent further non-cycloplegic subjective refraction to obtain their best-corrected VA (BCVA) at monocular fashion.

Detailed eye examination was carried out by an experienced ophthalmologist (M.H.)

using a slit lamp (Topcon SL-8Z, Topcon Inc, Tokyo, Japan) and +78D lens (at 16x magnification), both before and after of pupil dilation. Noncycloplegic refraction data were obtained using a handheld auto-refractor (ARK-30; Nidek, Crop, Gamagori, Japan) and spherical equivalent (SE) was calculated as sphere plus 1/2 of the cylinder. A questionnaire was also conducted to obtain personal information including age, gender, patients' income, education level, hypertension, diabetes, and other medical history. Hypertension and diabetes was defined based on self-reported history.

United States (US) criteria for visual impairment and blindness was used in this current study. Visual impairment (VI) was defined as VA <20/40 in the better-seeing eye. Correctable VI was defined as participants with presenting VI in the better eye that could be improved to a BCVA of $\geq 20/40$ after subjective refraction, while non-correctable VI was defined as participants with presenting VI in the better eye that couldn't be improved to normal or near normal after subjective refraction. Persistent correctable VI was defined as participants with correctable VI at baseline remained have correctable VI at the 5-year follow-up examination.

Statistical analysis

All statistical analyses were performed using Stata (ver. 10.0; Stata Corp., College Station, TX). Participants with missing values for PVA or BCVA both at baseline and 5-year follow-up visit were excluded from this current analysis. The 5-year progression of baseline correctable VI by age and gender was calculated. Age was defined as the age at baseline in the current analysis. . Student's t-test was used to compare continuous variables, while Pearson X² or Fisher's exact test were used for the comparison of categorical data. Univariate and multiple logistic regression models were used to investigate the associations of persistent VI with potential risk factors,

such as age, gender, education, income, hypertension, diabetes, and baseline SE, odds ratios (OR) with 95% confidence intervals (CI) are presented. Risk factors for developing from correctable VI to non-correctable VI were also investigated using univariate and multiple logistic regression models. A P value of <0.05 was considered as statistically significant.

RESULTS

Among the 1405 participants at baseline examination, visual acuity data were not available in 6 participants who were unfit for examination, leaving 1399 people available for the current analysis, Of the 1399 participants with complete examination data, 1079 (77.1%) had no VI, 132 (9.4%) had non-correctable VI and 188 (13.4%) had correctable VI. The prevalence of correctable VI increased with age, from 6.5% in the 50-59 years age group to 21.5% in the 70+ years age group ($P < 0.0001$). The prevalence of correctable VI was the same for male and female gender (13.4%, $P = 0.997$) (Table 1).

Table 1: Prevalence of visual impairment (VI) at baseline by age and gender

Age Group	Total number	No visual impairment N (%)	Correctable VI N (%)	Non-correctable VI N (%)	
				With vision improvement	Without vision improvement
Men					
50-59 years	210	197(93.8)	13(6.2)	0	0
60-69 years	175	142(81.1)	26(14.9)	5(2.9)	2(1.1)
+70years	225	146(64.9)	43(19.1)	23(10.2)	13(5.8)
Total	610	485(79.5)	82(13.4)	28(4.6)	15(2.5)
Women					

50-59 years	264	245(92.8)	18(6.8)	3(1.1)	0
60-69 years	228	194(85.1)	19(8.3)	18(7.9)	3(1.3)
+70years	297	155(52.2)	69(23.2)	95(32.0)	10(3.4)
Total	789	594(75.3)	106(13.4)	116(14.7)	13(1.7)
Combined					
50-59 years	474	442(93.3)	31(6.5)	1(0.2)	0
60-69 years	403	336(83.4)	45(11.2)	17(4.2)	5(1.2)
+70years	522	301(57.7)	112(21.5)	86(16.5)	23(4.4)
Total †	1399	1079(77.1)	188(13.4)	104(7.4)	28(2.0)

† Of 1405 participants, 6 VA missed for being unfit for examination.

Among the 188 participants with baseline correctable VI, 25(13.3%) died and 6 (3.19%) relocated during the 5-year follow up, leaving 157 participants (83.5%) eligible for follow-up examination. In addition, 31 participants (19.7%) refused and 8 (5.1%) couldn't be contacted, thus a total of 118 participants (75.2% of 157 eligible) were re-examined at the 5 year follow-up. Another 3 participants were further excluded because of missing data on VA at 5-year follow-up examination. Of the remaining 115 participants with baseline correctable VI, 43 (37.4%) had persistent correctable VI, 39 (33.9%) progressed to non-correctable VI, and 33 (28.7%) were no longer VI over 5-year period (Table 2). Of the 43(37.4%) participants with persistent correctable impairment, 20 (46.5%) could be improved from PVA of $<20/40 \sim \geq 20/63$, 22 (51.2%) from $<20/63 \sim \geq 20/200$ and 1 (2.3%) from $<2/200$ to visual acuity $\geq 20/40$ after refractive correction. Among the 39 participants with non-correctable VI at 5-year follow-up, cataract (26 participants, 66.7%) was the most frequent primary cause, followed by myopic degeneration (8 participants, 20.5%), epiretinal membranes (2 participants, 5.1%), primary open angle glaucoma (1 participants, 2.6%), diabetic retinopathy (1 participants, 2.6%), and age-related maculopathy (1 participants, 2.6%).

Table 2: Five-year visual outcomes of correctable visual impairment (VI) by age and gender

Age Group	Total number	No longer visually impaired N (%)	Persistent Correctable VI N (%)	Non-correctable VI	
				With vision improvement but still <20/40 N (%)	Without vision improvement at all N (%)
Men					
50-59 years	9	3(33.3)	6(66.7)	0	0
60-69 years	11	6(54.6)	1(9.09)	4(36.4)	0
+70years	8	2(25.0)	1(12.5)	4(50.0)	1(12.5)
Total	28	11(39.3)	8(28.6)	8(28.6)	1(3.6)
Women					
50-59 years	14	3(21.4)	8(57.1)	3((21.4)	0
60-69 years	10	5(50.0)	4(40.0)	1(10.0)	0
+70years	20	5(25.0)	6(30.0)	8(40.0)	1(5.0)
Total	44	13(29.6)	18(40.9)	12(27.3)	1(1.3)
Combined					
50-59 years	27	7 (25.9)	17(63.0)	3(11.1)	0
60-69 years	33	13(39.4)	12(36.4)	6(18.2)	2(6.06)
+70years	55	13(23.6)	14(25.5)	24(43.6)	4(7.3)
Total	115	33(28.7)	43(37.4)	33(28.7)	6(5.2)

Compared to those who were no longer visually impaired at 5-year follow-up, participants with persistent correctable VI and non-correctable VI had a more myopic SE (-2.41D vs. -0.10 D, $P=0.0063$) at baseline. Participants with low income<1000RMB/month (58.0% vs 39.4%, $P=0.071$) tended to have persistent VI although this was not statistically significant. No statistically significant differences were found between baseline age, gender, education, hypertension, diabetes, and

baseline PVA in better-seeing eye across the two groups. In multivariate logistic regression, significant associated factors for participants with persistent VI were older (OR=3.58, 95%CI=1.14~11.2, P=0.029), had income<1000RMB/month (OR=2.96, 95%CI=1.10~7.99, P=0.032), and more myopia SE (OR=0.82 per increased diopter, 95%CI=0.71~0.95, P=0.007)(Table 3).

Compared to those with persistent correctable VI at 5-year follow-up, participants who developed to non-correctable VI were older 71.8% vs 32.6%, P<0.001). More myopia SE tended to have non-correctable VI (-3.14±4.16 vs -1.82±4.35, P=0.1858) although this was not statistically significant. No statistically significant differences were found between baseline gender, education, income, hypertension, and diabetes across the two groups. In multivariate logistic regression, significant risk factors for developing to non-correctable VI were old age (OR=10.5, 95%CI=2.38~46.6, P=0.002) and more myopia SE (OR=0.79 per increased diopter, 95%CI=0.67~0.93, P=0.005) (Table 4).

Table 3: Association analysis of participants with persistent visual impairment and those no longer visually impaired at the 5-year follow-up examinations

Characteristic	With VI at follow-up N (%)	Without VI at follow-up N(%)	Univariate Analysis		Multivariate analysis [†]	
			OR (95%CI)	P-value	OR(95%CI)	P-value
Total number	82(100)	33(100)				
Age						
<70years (%)	40(48.8)	20(60.6)	Ref		Ref	
≥70years(%)	42(51.2)	13(39.4)	1.62(0.71,3.67)	0.253	3.58(1.14,11.2)	0.029
Female (%)	48(58.5)	20(60.6)	0.92(0.40, 2.09)	0.838	0.57(0.21,1.65)	0.313
Without education (%)	49(60.5)	20(60.6)	1.00(0.44,2.29)	0.991	0.52(0.16,1.69)	0.277
Low income (<1000 RMB/month, %)	47(58.0)	13(39.4)	2.13(0.93,4.86)	0.073	2.96(1.10,7.99)	0.032
Hypertension (present, %)	31(37.8)	17(53.1)	0.54(0.23, 1.22)	0.139	0.50(0.18,1.37)	0.176
Diabetes (present, %)	11(13.4)	4(12.2)	1.12(0.33,3.82)	0.852	3.54(0.72,17.4)	0.119
Spherical equivalent(D, Mean±SD)	-2.41±4.29	-0.10±3.13*	0.85(0.73,0.96)	0.009	0.82(0.71,0.95)	0.007

*P<0.05

Abbreviations: VI= Visual impairment; OR= Odds Ratio; 95%CI=95% Confidence interval; Ref=reference; D=Diopter; SD =Standard deviation

[†]Adjusted for age, gender, education status, levels of monthly income, hypertension, diabetes, and spherical equivalent

Table 4: Association analysis of participants with persistent correctable visual impairment and those who progressed to non-correctable visual impairment at the 5-year follow-up examinations

Characteristic	persistent correctable VI N (%)	non-correctable VI N(%)	Univariate Analysis		Multivariate analysis†	
			OR (95%CI)	P-value	OR(95%CI)	P-value
Total number	43(100)	39(100)				
Age						
<70years (%)	29(67.4)	11(28.2)	Ref		Ref	
≥70years(%)	14(32.6)	28(71.8) *	5.27(2.04,13.6)	0.001	10.5(2.38,46.6)	0.002
Female (%)	27(62.8)	21(53.9)	0.69(0.29, 1.67)	0.412	0.33(0.10,1.13)	0.078
Without education (%)	22(51.2)	27(71.1)	2.34(0.93,5.89)	0.070	2.54(0.56,11.4)	0.225
Low income (<1000 RMB/month,%)	27(62.8)	20(52.6)	0.66(0.27,1.59)	0.356	0.66(0.21,2.12)	0.487
Hypertension (present,%)	17(39.5)	14(35.9)	0.86(0.35, 2.10)	0.735	0.72(0.22,2.37)	0.590
Diabetes (present,%)	6(14.0)	5(12.8)	0.91(0.25,3.25)	0.881	1.11(0.22,5.68)	0.903
Spherical equivalent(D , Mean±SD)	-1.82±4.35	-3.14±4.16	0.93(0.83,1.04)	0.190	0.79(0.67,0.93)	0.005

* $P < 0.05$

Abbreviations: VI= Visual impairment; OR= Odds Ratio; 95%CI=95% Confidence interval; Ref=reference; D=Diopter; SD =Standard deviation

†Adjusted for age, gender, education status, levels of monthly income, hypertension, diabetes, and spherical equivalent

DISCUSSION

Our analysis showed that 13.4% of those aged 50 years and older in this urban district had correctable VI at baseline. During the 5-year follow up period, approximately 1/3 of these people remained correctable VI, another 1/3 progressed to non-correctable VI, whereas the remaining 1/3 were no longer visual impaired. Significant risk factors for participants with persistent VI were older, had income<1000RMB/month, and more myopia SE. Older age and more myopia SE were risk factor for developing from correctable VI to non-correctable VI . We believe that our results could help better understanding the natural course of correctable VI and aid in making future strategic planning.

The prevalence of correctable VI at baseline was 13.4%. This is much higher than that of the Blue Mountains Eye Study (age>49 years),¹¹ which reported that 7.5% of the participants had correctable VI, it was also higher than what was found in the Shihpai Eye Study(9.55%),¹² the SEE project(5.6% of whites and 10.4% of blacks),¹³ and the Baltimore Eye Survey(7.8%).¹⁴ We believe that the relative higher prevalence of correctable VI in this current study was attributable to social economic status and less accessibility of eye care service. Increasing age was the most important predisposing factor for developing correctable VI in our study, this is consistent with the Blue Mountains Eye Study¹¹ and the Shihpai Eye Study¹² and was confirmed by our longitudinal analysis that showed older age was a significant risk factor for participants with persistent correctable VI. Myopic shift secondary age-related nuclear opacity might compromise distance vision and in part contribute to the correctable VI cases at follow-up visit.

During the 5-year period, 71.3% of the participants with correctable VI at baseline

remained to have VI, of which 37.4% were persistent correctable VI. This is higher than the 27.2% reported by Blue Mountain Eye Study.¹⁵ This may be due to a difference in social-economic characteristics between these two countries. People in less developed areas might have lower awareness and less utilization of eye care services. Economic status might be another barrier to the accessibility of eye services.

There were 33.9% of participants with correctable VI at baseline that developed non-correctable VI, most of them were secondary to the development of age-related eye disease, such as cataract. Many population-based studies showed that cataract was the leading cause of BCVA based VI and blindness.^{5,16,17} Cataract surgery might be of help to reduce the number of uncorrectable VI.

We found a significant association between income and 5-year outcomes of correctable VI in our study. People with lower income tended to have persistent VI. In the Blue Mountains eye study,¹⁸ higher prevalence of under-corrected refractive error was found in those receiving a government pension, who were trades persons or laborers, with a lower educational status. People with lower income may have lower degree of health awareness, or less likely to seek medical aid or accept treatment. This is especially true in China, as the Chinese health insurance system mainly covers chronic systemic diseases, and the reimbursement ratio for eye disease is relatively low. Financial considerations have often been identified as the primary reason for non-attendance to eye care services, for example the unaffordability for cataract surgery, or failure to purchase spectacles^{19,20}. The survey in Timor-Leste showed that 96% of persons who needed spectacles were willing to wear them, but half of them were not willing to pay¹⁵. In summary, these findings suggest that both perceived costs of attending an eye care practitioner and lack of knowledge of the potential

benefits from refractive correction inhibit many people from seeking assistance.

Many cross-sectional studies found that myopia was an independent risk factor for correctable VI.¹⁵ Our results also demonstrated that participants with myopic SE are at highest risk of having persistent correctable visual impairment or non-correctable VI. It is partly because that unlike hyperopia which caused blurred vision both at far and near distance, people with myopia and potentially better near vision might have satisfied with their vision in daily life and therefore ignore need for a glasses to obtain better distance vision.

Strengths of the current study include a population-based design and the availability of longitudinal data on correctable VI. Several potential limitations of this study needs to be mentioned. The relatively low follow-up rate may influence the validity of our results. In addition, considering that younger subjects were more likely to participate in the five-year follow-up examinations, the outcomes of those with persistent correctable VI may be underestimated.

In conclusion, our study indicated that among participants with correctable VI at baseline, 1/3 had persistent correctable VI and 1/3 was converted to normal or near normal over a 5-year period. Our findings provide evidence for the necessities in providing appropriate refractive correction service for people in need (potentially falling into the correctable VI category). Although simple spectacles correction may eliminate a large proportion of VI, patient awareness is another issue to be solved. Both economic factors and lack of patient awareness for the need of refractive correction should be taken into consideration in the future health planning process.

REFERENCES

1. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. *The British journal of ophthalmology* 2012; **96**: 614-8.
2. Wang JJ, Mitchell P, Cumming RG, Smith W, Blue Mountains Eye S. Visual impairment and nursing home placement in older Australians: the Blue Mountains Eye Study. *Ophthalmic epidemiology* 2003; **10**: 3-13.
3. Ivers RQ, Cumming RG, Mitchell P, Attebo K. Visual impairment and falls in older adults: the Blue Mountains Eye Study. *Journal of the American Geriatrics Society* 1998; **46**: 58-64.
4. Chia EM, Mitchell P, Rochtchina E, Foran S, Wang JJ. Unilateral visual impairment and health related quality of life: the Blue Mountains Eye Study. *The British journal of ophthalmology* 2003; **87**: 392-5.
5. Huang S, Zheng Y, Foster PJ, Huang W, He M, Liwan Eye S. Prevalence and causes of visual impairment in Chinese adults in urban southern China. *Archives of ophthalmology* 2009; **127**: 1362-7.
6. Li J, Zhong H, Cai N, Luo T, Li J, Su X, Li X, Qiu X, Yang Y, Yuan Y, Yu M. The prevalence and causes of visual impairment in an elderly Chinese Bai ethnic rural population: the Yunnan minority eye study. *Investigative ophthalmology & visual science* 2012; **53**: 4498-504.
7. Liang YB, Friedman DS, Wong TY, Zhan SY, Sun LP, Wang JJ, Duan XR, Yang XH, Wang FH, Zhou Q, Wang NL, Handan Eye Study G. Prevalence and causes of low vision and blindness in a rural chinese adult population: the Handan Eye Study. *Ophthalmology* 2008; **115**: 1965-72.
8. McCarty CA, Taylor HR. Myopia and vision 2020. *American journal of ophthalmology* 2000; **129**: 525-7.

9. Pizzarello L, Abiose A, Ffytche T, Duerksen R, Thulasiraj R, Taylor H, Faal H, Rao G, Kocur I, Resnikoff S. VISION 2020: The Right to Sight: a global initiative to eliminate avoidable blindness. *Archives of ophthalmology* 2004; **122**: 615-20.
10. He M, Foster PJ, Ge J, Huang W, Zheng Y, Friedman DS, Lee PS, Khaw PT. Prevalence and clinical characteristics of glaucoma in adult Chinese: a population-based study in Liwan District, Guangzhou. *Investigative ophthalmology & visual science* 2006; **47**: 2782-8.
11. Foran S, Rose K, Wang JJ, Mitchell P. Correctable visual impairment in an older population: the blue mountains eye study. *American journal of ophthalmology* 2002; **134**: 712-9.
12. Kuang TM, Tsai SY, Hsu WM, Cheng CY, Liu JH, Chou P. Correctable visual impairment in an elderly Chinese population in Taiwan: the Shihpai Eye Study. *Investigative ophthalmology & visual science* 2007; **48**: 1032-7.
13. West SK, Munoz B, Rubin GS, Schein OD, Bandeen-Roche K, Zeger S, German S, Fried LP. Function and visual impairment in a population-based study of older adults. The SEE project. Salisbury Eye Evaluation. *Investigative ophthalmology & visual science* 1997; **38**: 72-82.
14. Tielsch JM, Sommer A, Witt K, Katz J, Royall RM. Blindness and visual impairment in an American urban population. The Baltimore Eye Survey. *Archives of ophthalmology* 1990; **108**: 286-90.
15. Foran S, Rose K, Wang JJ, Thiagalingam S, Mitchell P. Five-year outcome of correctable visual impairment: the Blue Mountains Eye Study. *Clinical & experimental ophthalmology* 2002; **30**: 155-8.
16. Hong T, Mitchell P, Burlutsky G, Fong CS, Rochtchina E, Wang JJ. Visual impairment and subsequent use of support services among older people: longitudinal findings from the Blue Mountains Eye Study. *American journal of*

ophthalmology 2013; **156**: 393-9 e1.

17. Gunnlaugsdottir E, Arnarsson AM, Jonasson F. [Visual impairment and blindness in Icelanders aged 50 years and older - the Reykjavik Eye Study]. *Laeknabladid* 2013; **99**: 123-7.
18. Thiagalingam S, Cumming RG, Mitchell P. Factors associated with undercorrected refractive errors in an older population: the Blue Mountains Eye Study. *The British journal of ophthalmology* 2002; **86**: 1041-5.
19. Saw SM, Foster PJ, Gazzard G, Friedman D, Hee J, Seah S. Undercorrected refractive error in Singaporean Chinese adults: the Tanjong Pagar survey. *Ophthalmology* 2004; **111**: 2168-74.
20. Munoz B, West SK, Rodriguez J, Sanchez R, Broman AT, Snyder R, Klein R. Blindness, visual impairment and the problem of uncorrected refractive error in a Mexican-American population: Proyecto VER. *Investigative ophthalmology & visual science* 2002; **43**: 608-14.