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Original Article – Clinical Science

Incidence and correction of vision impairment among elderly population in southern urban China

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Short running title: Incidence and correction of vision impairment
Received 3 September 2018; accepted 22 October 2018
Funding sources: This work was supported by the Fundamental Research Funds of the State Key Laboratory in Ophthalmology, National Natural Science Foundation of China

[grant numbers 81125007], Science and Technology Planning Project of Guangdong Province, China [grant numbers 2013 B20400003].
Financial disclosure: Prof. He receives support from the University of Melbourne at Research Accelerator Program and the CERA Foundation. The Centre for Eye Research Australia receives Operational Infrastructure Support from the Victorian State Government. The sponsor or funding organization had no role in the design or conduct of this research.
Conflict of interest: None

ABSTRACT

Importance: Data on the incidence of presenting vision impairment (PVI) and spectacle coverage rate (SCR) in urban China is limited.

Background: To estimate the 6-year incidence and risk factors for PVI and the SCR in urban Southern China.

Design: Population-based cohort study.

Participants: 1817 participants aged ≥35 years were identified from Guangzhou in 2008 for baseline and 1427 attended follow-up examination in 2014.

Methods: Presenting VA (PVA) was measured using the ETDRS chart with habitual spectacles. Participants with PVA ≤20/40 underwent subjective refraction at the follow-up visit. Incidence of PVI was calculated using the WHO and US criteria respectively. The met-need SCR was defined as the percentage of participants with PVA <20/40 that could be improved to ≥20/40 after correction.

Main Outcome Measures: Incidence of PVI and SCR.

Results: Incidence of PVI was 8.3% (95%CI, 6.9-9.8) and 12.2% (95%CI, 10.5-14.0) based on the WHO and US definition, respectively. Older age, female, lower education level, more myopic spherical equivalent and worse PVA at baseline were significantly related to a higher PVI incidence based on the WHO criteria, with similar associations identified using the US criteria except for gender. The overall met-need SCR was 42.5%, and it was lower among the elderly, more hyperopic participants, or participants with lower education level.

Conclusions and relevance: The incidence of PVI is high in urban Southern China and spectacle wearing is available in less than half of those in need. This highlights the needs to promote spectacle coverage even in the urban population.

Key Words: incidence, vision impairment, presenting visual acuity, aging population, spectacle coverage, WHO, population-based study.

1. INTRODUCTION

According to the 2017 World Health Organization (WHO) estimation, there were 253 million people with vision impairment (VI) and 36 million with blindness worldwide.[1] Vision Impairment poses a substantial threat to quality of life by limiting functional and social life, as well as emotional well-being.[2-4] With the ever-growing aging population, VI and blindness is projected to pose enormous social and economic burdens to the whole society, especially in developing and populous countries.[5,6] Reported prevalence of VI in adults ranged from 2.9% to 15.8% in China.[7-9] However, information on the incidence of VI in China, an essential knowledge for estimating the demand in the community in the perspective of future public health planning, is still limited.[8,10]

Given refractive error is the main cause of VI globally, appropriate spectacle correction is the most effective way to address this burden.[10-13] Previous studies investigating the spectacle coverage rate (SCR) in China reported varying rates ranging from 44.1% to 71.2%.[14,15] However, to date, there is a paucity of up-to-date data on the SCR in urban China, where 57% of the population resides.[16] In addition, the global prevalence of myopia is increasing rapidly during the recent decades, especially in East and Southeast Asia.[17] Reported myopia prevalence had exceeded 90% among teenagers in China. Thus, a better understanding of the current spectacles coverage rate (SCR) is clearly warranted to assist with planning of refractive service delivery and promoting eye care service uptake.

We conducted a 6-year longitudinal, population-based study to investigate: (1) the incidence and risk factors of presenting VI (PVI); (2) the spectacle correction rate and performance in urban Southern China.

2. METHODS

2.1 Study Population

Participants aged 35 years or older were selected by random cluster sampling from the Yuexiu district of Guangzhou, China, which is a large urban area with an estimated population of 10.18 million. Demographic information including age, gender and educational level were documented at baseline in 2008. Details of the sampling and recruitment methodology have been described elsewhere.[18,19] Briefly, 1817 of 2286 (79.5%) eligible participants were enrolled at baseline and all were invited for a follow-up examination in 2014. Baseline and follow-up examinations were conducted using the same protocols at Zhongshan Ophthalmic Center (ZOC) or in local community facilities or homes for individuals with mobility restrictions or limited free time. Study protocols were approved by the World Health Organization Secretariat Committee on Research Involving Human Subjects and by the institutional review board at ZOC in Guangzhou, China. Written informed consent was obtained from all participants and the study was conducted in accordance with the tenets of the Declaration of Helsinki. The participants did not receive any financial compensation.

2.2 Procedures

Presenting visual acuity (PVA) was measured indoor under ambient lighting with a LogMAR ETDRS tumbling E chart (Precision Vision, La Salle, Illinois, USA) per

standardized protocol. Non-cycloplegic automated refraction was carried out for all participants at baseline and at the follow-up visit using the same device after proper calibration (KR-8800; Topcon Corp, Japan). Five consecutive measurements were performed for each eye with the mean recorded as the final value. At the 2014 follow-up, uncorrected VA was measured for all participants and subjective refraction was performed for participants with PVA ≤ 20/40 to obtain their best-corrected visual acuity. Slit-lamp examination of the anterior segment was performed by an ophthalmologist throughout the study.

2.3 Definitions

Two definitions were used to define PVI and blindness.[20] According to the WHO definition: PVI was defined as binocular PVA <20/60 to 20/400 and presenting blindness was defined as binocular PVA <20/400. Definitions for PVI and blindness according to the United States (US) criteria were binocular PVA <20/40 to 20/200 and PVA <20/200, respectively. Based on these two criteria, incidence of PVI was calculated as the percentage of participants without PVI at baseline who developed PVI during the follow-up period. Similarly, incidence of presenting blindness was calculated as the percentage of participants without blindness at baseline who developed blindness during follow-up. Spectacle coverage for refractive error was assessed using the US definition, with "met need" defined as those with uncorrected binocular VA <20/40 who had spectacles that improved their VA to ≥20/40. "Unmet need" was defined as those with uncorrected VA <20/40 but did not have spectacles or were under-corrected. Spectacle coverage rate was calculated by the following formula: spectacle coverage rate = met need / (met need + unmet need).

2.4 Data Management and Analyses

Spherical equivalent (SE), calculated as spherical power plus half of cylindrical power, was used to represent refraction. Baseline refractive state was categorized into myopia (SE < -0.5D), emmetropia (-0.5D ≤ SE ≤ +0.5D) and hyperopia (SE > +0.5D). Age was categorized into four groups: 35-44, 45-54, 55-64 and ≥65, based on the age obtained at baseline. Education level was dichotomized as less than high school and high school or above.

All statistical analyses were performed using STATA Statistical Software: Release 12.0 (StataCorp LP, Colleage Station, TX). Group t-test and trend-analysis were used to assess the difference in incidence of PVI in different groups by age, gender, education, refraction and baseline PVA. Multiple linear regression analysis was used to assess the association between incident PVI and potential risk factors. Chi-square test was used to assess the difference between spectacle coverage among different groups. P-values of <0.05 were considered statistically significant.

3. RESULTS

Of the 1817 baseline participants, 1427 (78.5%) attended the follow-up examinations in 2014. Follow-up participants were significantly younger than non-participants, with a mean (standard deviation) age at baseline of 52.3 (11.6) years old and 54.9% were female. Detailed differences in characteristics between follow-up participants and non-participants have been reported previously.[21]

Based on the WHO and US definitions, the incidence of PVI in adults residing in urban China was 8.3% (95%CI, 6.9 to 9.8) and 12.2% (95%CI, 10.5 to 14.0), respectively (Table 1). Using the WHO definition, participants aged 65 years or older had

significantly higher incidence compared with their younger counterparts (28.3% vs. 4.8%; P<0.001). Females (P=0.003), participants with an education level of lower than high school (P<0.001) and those with poorer PVA at baseline (P<0.001) also had a higher PVI incidence. Emmetropic participants at baseline had a significantly lower incidence compared to myopic or hyperopic participants (P<0.001). There were no incident blindness cases reported at the 2014 follow-up using the WHO criteria. However, when adopting the US definition, the incidence of presenting blindness was 0.14% (95%CI, 0.00 to 0.33).

Multiple regression analysis showed that older age (P<0.001), female gender (P=0.01) and worse PVA (P<0.001) at baseline were associated with incident PVI. Participants with myopia at baseline were at higher odds of incident PVI compared to those with emmetropia (P<0.001) (Table 2). With the exception of female gender, all of the above associations remained after adopting the US definition. In addition, participants with hyperopia were at a higher risk of incident PVI than those with emmetropia using the US definition (P=0.03).

Of the 327 participants with uncorrected VA<20/40 at the 2014 follow-up visit, only 139 had spectacles to achieve a PVA of ≥20/40, resulting in an overall SCR of 42.5% (Table 3). Participants of older age and those with a lower level of education had a lower SCR (both with P<0.001). Refractive status was also related to SCR, with an SCR of 56.6%, 0.0% and 18.3% for myopes, emmetropes and hyperopes, respectively.

Table 4 shows the potential vision improvement with the best refractive correction at the 2014 follow-up visit. Of the 1427 participants, 1184 (83.0%) had PVA of ≥20/40 with their habitual spectacles. An improvement in VA of at least 2 lines could be

achieved in 17.1% (203/1184) of participants. There were 186 participants (13.0%) with VA correctable to ≥20/40 but did not have any habitual correction. Of which, 91.4% could achieve a VA improvement of at least 2 lines and nearly 60% could achieve a VA improvement by at least 4 lines. In addition, for the 57 participants whose VA could not be improved to ≥20/40, VA of 21 participants (36.9%) could be improved by at least 2 lines from their PVA with spectacle correction.

4. DISCUSSION

This study documents the 6-year incidence and risk factors of PVI, as well as the SCR, of adults residing in urban Southern China. Strengths of the study include a large sample size, a high follow-up rate, a population-based design and the application of standardized method throughout the study. Results from our study offer important practical implications in planning for eye care services in urban China.

Presenting VA was utilized in the present study as it better reflects normal daily functional requirements compared to uncorrected or best-corrected VA. Comparisons between VI incidences should be made with caution in consideration of the difference in study population, design and definitions. Using the WHO criteria, incidence of PVI identified in our study (8.33%, ≥35 years old) was higher than that reported in Melbourne (1.38%,≥40 years old),[11] Shahroud (1.02%, 40-64 years old)[12] and Los Angeles (1.8%, ≥40 years old),[22] but lower than that in Kenya (11.9%, ≥50 years old).[23] When compared with studies conducted in China, the Beijing Eye Study only reported incidence of best-corrected VI (1.7%).[10] The Liwan Eye Study, which is also based on an urban Southern Chinese population, reported a higher incidence of PVI compared with our study (WHO criteria, 12.4% vs. 8.33%; US criteria, 20.6% vs.

12.2%).[13] This could largely be attributed to that participants in the Liwan Eye study were relatively older (mean age: 63.4 years old), as the age-specific VI incidence using the US criteria for participants aged 50-59 and 60-69 in our study (8.5% and 20.1%, respectively) were higher than the corresponding figures in Liwan (2.5% and 6.0%, respectively).

In line with previous reports,[11] age was the strongest risk factor for incident VI in the present study. Age-related eye diseases including cataract and age-related macular degeneration pose a higher risk of VI in the elderly.[24] We also found that a lower education level and baseline refractive status were associated with incident PVI, which is consistent to previous studies.[13,25] Females had a higher PVI incidence than males, and this difference became statistically significant when adopting the more stringent WHO criteria. It has been reported that females have less access to eye care services compared to males,[26] and their higher tolerance of poor vision and worse financial situation could also lead to untreated eye diseases.[27] This highlights an increased awareness of the importance of promoting eye care service for women.

It is widely acknowledged that refractive error is the leading cause of PVI and spectacles is the most efficient and cost-effective way to ease this burden,[10,13] however SCR in urban China remains unsatisfactory. Based on our findings, the met-need SCR in urban Southern China (42.5%) is much higher than that reported in rural areas including Niger (≥40 years; 3.49%)[28] and Bangladesh (≥30 years; 25.2%),[29] similar to Shanghai (≥60 years, 44.12%)[15] but much lower than Taiwan (71.2%, ≥65 years),[14] Tehran (66%, ≥65 years) and Australia (93.5%, ≥40 years).[30,31] Besides the difference in ethnic background and age distributions examined, one may speculate that users' affordability and accessibility to eye care may explain the lower SCR in less-

developed regions. In our study, younger participants were more likely to have a "met-need" refractive error correction. Older people might lack the awareness and demand for vision. Similarly, people with lower education level also had lower SCR, which may be partly explained by poor awareness and affordability to care.

It is not surprising that individuals with myopia had a higher SCR compared to their hypermetropic and emmoetropic counterparts, as they tend to experience blurred vision and commence spectacle wear earlier in life. However, the low coverage among the hyperopes should raise our attention as they may not realize the existence of vision problems and importance of addressing them. Given a current SCR of 42.5%, increased efforts are required to develop an efficient strategy for providing low-cost refractive correction to the people in need, especially the higher risk populations identified above.

In addition to the SCR, we also investigated the potential VA improvement with best refractive correction compared to habitual spectacles. We report that 27.6% of the participants could achieve a VA improvement of at least 2 lines, and 8.3% by at least 4 lines with their best correction. This compares to 16.5% and 5.9%, respectively, in Tehran.[30] Furthermore, nearly half of the population did not achieve their optimal visual status with their habitual spectacles. These findings further highlight the need to strengthen health education and promote an annual refraction examination. Recently The New York Times has reported the challenge of uncorrected vision impairment and commented that spectacles is a simple way to improve a billion lives. With the growing aging population and increasing prevalence of refractive errors, how to improve SCR among the elderly would become an urgent issue in the near future.

Potential limitations of our study should be noted. First, specific causes of PVI were not determined in this study. However as 96% of the study participants could achieve VA ≥20/40 with best refractive correction, we regard under-corrected refractive error as the primary cause of PVI.[10,13] Second, we only assessed the incidence of PVI, but not uncorrected and best-corrected VI. Despite this, PVA best reflects the real-world situation and aids future strategic planning. Lastly, SCR was calculated based on the 2014 follow-up participants instead of all baseline participants as subjective correction was not performed at baseline. Given that participants at the 2014 follow-up examinations were younger with better baseline VA, we suggest an even higher PVI incidence and lower SCR for the whole population-based cohort.

In conclusion, the incidence of PVI is high (WHO, 8.33%; US, 12.2%) in urban Southern China and is expected to increase with the aging society. The relatively low spectacle coverage and the unsatisfactory quality of optical correction could be a future health policy target. More efforts are needed to establish cost-effective strategies for promoting eye care services.

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TABLES

Table 1: Six-year incidence of presenting distance vision impairment

Characteristics	WHO Criteria			Unites States Criteria		
	No. at risk	Incidence % (95% CI)	P-value	No. at risk	Incidence % (95% CI)	P-value
Age			<0.001			<0.001
35-44	382	4.45 (2.37 to 6.53)		374	5.61 (3.27 to 7.96)	
45-54	502	2.39 (1.05 to 3.73)		491	5.70 (3.64 to 7.76)	
55-64	280	9.64 (6.16 to 13.1)		272	15.1 (10.8 to 19.4)	
≥65	205	28.3 (22.1 to 34.5)		180	39.4 (32.2 to 46.7)	
Sex			0.003			0.011
Male	627	5.90 (4.05 to 7.75)		606	9.74 (7.37 to 12.1)	
Female	742	10.4 (8.18 to 12.6)		711	14.3 (11.8 to 16.9)	
Education			<0.001			<0.001
Less than high school	444	15.1 (11.7 to 18.4)		417	20.6 (16.7 to 24.5)	
High school or above	925	5.08 (3.67 to 6.50)		900	8.33 (6.52 to10.1)	
Refraction			<0.001			<0.001
Myopia	390	13.6 (10.2 to 17.0)		361	18.0 (14.0 to 22.0)	
Emmetropia	580	3.28 (1.82 to 4.73)		575	5.04 (3.25 to 6.84)	
Hyperopia	399	10.5 (7.50 to 13.6)		381	17.6 (13.7 to 21.4)	
Presenting VA			<0.001			<0.001
20/20	803	1.87 (0.93 to 2.81)		803	3.74 (2.42 to 5.05)	
20/25	295	6.78 (3.89 to 9.67)		295	14.9 (10.8 to 19.0)	
20/32	149	20.1 (13.6 to 26.6)		149	34.9 (27.2 to 42.6)	
20/40	70	30.0 (19.0 to 41.0)		70	50.0 (38.0 to 62.0)	
20/50	52	53.8 (39.8 to		-	-	

		67.9)		
Total	1369	8.33 (6.86 to 9.79)	1317	12.2(10.5 to 14.0)

WHO: world health organization; CI: confidence interval; VA: visual acuity.

Table 2: Multiple regression of potential risk factors for incident presenting vision impairment

Factors	WHO Criteria		Unites States Criteria	
	Odds Ratio (95% CI)	P Value	Odds Ratio (95% CI)	P Value
Age, y	1.06(1.04 to 1.08)	<0.001	1.07(1.05 to 1.09)	<0.001
Sex, female	1.84(1.14 to 2.96)	0.01	1.42(0.95 to 2.10)	0.09
Education level, high school or above	0.63(0.39 to 1.02)	0.06	0.66(0.44 to 1.00)	0.05
Baseline SE				
Myopia	3.21(1.68 to 6.16)	<0.001	3.76(2.17 to 6.52)	<0.001
Emmetropia	Reference		Reference	
Hyperopia	1.32(0.70 to 2.48)	0.39	1.79(1.07 to 3.00)	0.03
Presenting distance VA	0.01(0.003 to 0.04)	<0.001	0.02(0.01 to 0.06)	<0.001

CI: confidence interval; VA: visual acuity.

Table 3: Spectacle coverage for refractive errors at 2014 follow-up examination

Characteristic	Total number	Met Need (n)	Unmet Need (n)	Correction Coverage (%)	P value
Age at Baseline					<0.001
35-44	109	71	38	65.1	
45-54	76	36	40	47.4	
55-64	71	23	48	32.4	
≥65	71	9	62	12.7	
Sex					0.07
Male	139	67	72	48.2	
Female	188	72	116	38.3	
Education					<0.001
Less than high school	99	15	84	15.2	
High school or above	228	124	104	54.4	
Baseline refractive state					<0.001
Myopia	219	124	95	56.6	
Emmetropia	26	0	26	0.00	
Hyperopia	82	15	67	18.3	

Total	327	139	188	42.5

Table 4: Lines of improvement with best correction at the 2014 follow-up

Category	Total No.	Lines of improvement possible with best correction					
		0	1	2	3	4	≥5
Already corrected to 20/40	1184	813 (68.7)	168 (14.2)	141 (11.9)	62 (5.24)	-	-
Correctable to ≥20/40	186	-	16 (8.60)	24 (12.9)	33 (17.7)	53 (28.5)	60 (32.3)
Not Correctable to ≥20/40	57	15 (26.3)	21 (36.8)	13 (22.8)	3 (5.26)	2 (3.51)	3 (5.26)
Total	1427	828 (58.0)	205 (14.4)	178 (12.5)	98 (6.87)	55 (3.85)	63 (4.41)

Data expressed as No. (%).