Visual acuity and correctable visual impairment among Norwegian 65-year-olds

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Abstract

Prevalence of ocular disease and visual impairment increases with increased age. Population studies have shown that uncorrected refractive error is the main cause of visual impairment in the general population. The aim of this study was to examine visual acuity (VA) and the prevalence of correctable visual impairment among Norwegian 65-year-olds. The study had a cross-sectional design. A random sample born in 1943 ($n = 300$) was invited to participate. The participants underwent a full eye examination including: patient history, habitual visual acuity (HVA), refraction, best corrected visual acuity (BCVA) and examination of ocular health. The study was approved by the Regional Committee for Medical Research Ethics and reported to the Norwegian Social Science Data Services. Data was analyzed by Fisher's exact test, χ^2-test, χ^2-test, student t-test and logistic regression, $p < 0.05$ was considered statistically significant. Relative risk (RR) and odds ratio (OR) were calculated for correctable visual impairment. In all 129 subjects (43%) participated in the study. Three were excluded from the analysis due to missing data. The analysis included 126 subjects, 67 males and 59 females. None of the participants had permanent visual impairment. Mean (±SD) BCVA was logMAR -0.06 (±0.10) (Snellen decimal 1.2). Six subjects (5%) had correctable visual impairment, HVA logMAR > 0.3 (Snellen < 0.5) in the better eye, which improved with best correction to logMAR ≤ 0.3 (Snellen > 0.5). Eight subjects (6%) had clinically relevant undercorrected refractive error, i.e. an undercorrection in refractive error which when corrected produced an improvement in VA of 10 letters (2 lines on the logMAR chart) or more after refraction, when HVA was logMAR < 0.2 (Snellen 0.63). Long time (> 5 years) since last eye examination was an independent risk factor for correctable visual impairment, OR 2.7, 95% CI [1.0, 7.3], $p = 0.046$. Subjects with correctable visual impairment had either low refractive error or hyperopia (spherical equivalent refraction (SER) > -0.50 D), but there was no statistically significant association between refractive error and correctable visual impairment. Regular eye examination and correction of low refractive error and hyperopia can prevent unnecessary visual impairment in the elderly.

Introduction

Visual acuity (VA) declines and the prevalence of visual impairment increases with increasing age (Attebo, Mitchell, & Smith, 1996; Klaver, Wolfs, Vingerling, Hofman, & de Jong, 1998; Klein, Klein, Linton, & De Mets, 1991; Munoz et al., 2000; Sjöstrand, Laatikainen, Hirvela, Popovic, & Jonsson, 2011). The World Health Organization defines low vision as best corrected visual acuity (BCVA) in the better eye Snellen < 0.33, and blindness as BCVA in the better eye Snellen < 0.05 (WHO, 1973). Population studies have defined visual impairment as BCVA Snellen < 0.5 and this also defines the VA criterion for driving a private car (total weight ≤ 3500 kg and up to eight passenger seats) in Norway (Forskrift om førerkort m.m., 2004). In the Nordic countries the prevalence of visual impairment and blindness are 0.7-2.0% and 0.5-0.6% respectively (Buch et al., 2004; Buch, Vinding, La Cour, & Nielsen, 2001; Gunnlaugsdottir, Arnarsson, & Jonasson, 2008). Population studies have shown that a significant number of the general population is visually impaired due to uncorrected re-

fractive error. Correctable visual impairment is defined as habitual VA (HVA) Snellen < 0.5 in the better eye, which improves with best correction to BCVA ≥ 0.5. In the adult population 1-6% are visually impaired (HVA < 0.5) due to uncorrected refractive errors (Cedrone et al., 2009; Foran, Rose, Wang, & Mitchell, 2002; Munoz et al., 2000; VanNewkirk, Weih, McCarty, & Taylor, 2001). The Blue Mountains Eye Study (BMES), The Salisbury Eye Evaluation Study (SEE) and The Visual Impairment Project (VIP) have all shown that the prevalence of correctable visual impairment increases with increasing age (Liou, McCarty, Jin, & Taylor, 1999; Munoz et al., 2000; Thiagalingam, Cumming, & Mitchell, 2002). The BMES and the Beaver Dam Eye Study (BDES) found an increasing prevalence of hyperopia with increasing age (Attebo, Ivers, & Mitchell, 1999; Wang, Klein, Klein, & Moss, 1994), and the BMES also found an increase in mean astigmatism with increasing age. In the VIP uncorrected refractive error was the main cause of visual impairment among persons over 40 years, with a prevalence of 2.5% (VanNewkirk et al., 2001). In the SEE 3% of persons between 65-69 years were visually impaired with their habitual correction, of these one third had correctable visual impairment (Munoz et al., 2000). Further, 10% of the adult population in the BMES had clinically relevant undercorrected refractive error, i.e. an undercorrection in refractive error which when corrected produced an improvement in VA of 10 letters (2 lines on the logMAR chart) or more after refraction, when HVA was logMAR < 0.2 (Snellen 0.63) (Thiagalingam et al., 2002). This article will describe the prevalence of correctable visual impairment and undercorrected refractive error among Norwegian 65-year-olds. In addition factors associated with correctable visual impairment will be analyzed.

Methods

The study had a cross-sectional design. A random sample ($n = 300$) of females and males born in 1943 and living in Hedmark county ($N = 2039$) was invited to participate in the study. The sample was drawn from Postverket's (postal services) list of addresses and received an invitation to participate, information about the study and an informed consent form by postal mail. The sample was then contacted by telephone, and an appointment for the examination was made. Participation in the study was voluntary, and written informed consent was collected on the day of examination. Data collection was undertaken in October 2008. All participants ($n = 129$) underwent a clinical examination of visual function and the anterior and posterior segment of the eye. The examinations were undertaken in local optometric practices by 20 local optometrists with privilege to requisition diagnostic drugs. All participating optometrists received training in the examination procedure before study commencement. The study followed the tenets of the Declaration of Helsinki for research involving humans and was approved by the Regional Committee for Medical Research Ethics and reported to the Norwegian Social Science Data Services.

The clinical examination included: patient history, HVA, refraction, BCVA, low contrast acuity (2.5% contrast), near add, near VA, cover test, central visual field testing with Amsler chart, intraocular pressure (Goldmann or Non-Contact Tonometer),

slit lamp biomicroscopy of the lens, and dilated 5-field retinal photography.

Patient history was performed using a questionnaire and included questions on:
1. visual symptoms: blurred vision, variable vision, visual field defects, diplopia, metamorphopsia, and photopia,
2. vision- and eye examination: time since last examination, regular vision examination and regular ocular health examination,
3. optical correction,
4. known ocular disease: age-related macular degeneration (AMD), glaucoma, cataract, diabetic retinopathy and other vascular retinopathy, and
5. known systemic disease which may have an impact on vision: diabetes, cardiovascular disease, stroke and hypertension. The patient reported history was not verified.

VA at distance was measured monocularly and binocularly in normal room lighting (500-700 lux) using a logMAR chart (Good-Lite, ETDRS Original Series Chart R) at 4 m distance. VA was registered as the total number of letters read and in logMAR. Presenting acuity (HVA) was measured with the participant wearing habitual optical correction, i.e. own distance correction or no correction. BCVA was measured in trial frame after subjective refraction. Subjective refraction was measured with phoropter/trial frame based on retinoscopy or autorefractor measurements.

Low vision and blindness were defined according to the World Health Organization criteria as BCVA in the better eye Snellen < 0.33 (< 29 letters read/logMAR > 0.52) and < 0.05 (< 5 letters read at 2 m/logMAR > 1.30) respectively (WHO, 1973). Visual impairment was defined in accordance with the VA criteria for driving a private car (total weight ≤ 3500 kg and up to eight passenger seats) in Norway (Forskrift om førerkort m.m., 2004) and the definition used by The Blue Mountains Eye Study (BMES) (Foran et al., 2002) as BCVA Snellen < 0.5 (< 39 letters read/logMAR > 0.32). Correctable visual impairment was defined as in the BMES; HVA Snellen < 0.5 (< 39 letters read/logMAR > 0.32) in the better eye improving with best correction to BCVA Snellen ≥ 0.5 (≥ 39 letters read/logMAR ≤ 0.30) (Foran et al., 2002). Similarly, clinically significant undercorrected refractive error was defined as in the BMES as an undercorrection in refractive error which when corrected produced an improvement in VA of 10 letters (2 lines on the logMAR chart) or more after refraction, when HVA was logMAR < 0.2 (Snellen > 0.63) (Thiagalingam et al., 2002). Refractive error was defined by spherical equivalent power (SER); hyperopia: refractive error ≥ +0.50 D, myopia: refractive error ≤ -0.50 D and emmetropia: refractive error between -0.50 D and +0.50 D. The eye with the better HVA was used for analysis. Subjects with missing data for VA were excluded from the analysis.

Known ocular disease was defined as ocular disease reported by the participant: cataract, glaucoma, AMD, diabetic retinopathy and/or other ocular disease. Known systemic disease which may affect vision was defined as systemic disease reported by the participant: diabetes, cardiovascular disease, stroke and hypertension.

Data was analyzed in frequency and summation tables. Group difference was analyzed by Fisher's exact test, χ^2-test and student t-test. A p value < 0.05 was considered statistically significant. Factors associated with correctable visual impairment were analyzed using bivariate and multivariate logistic regres-

Table 1
Time since last vision examination, type of refractive error and type of habitual correction

	All participants (N = 126)		Females (n = 59)		Males (n = 67)	
Time since last vision examination [n (%)]						
< 1year	39	(31)	18	(31)	21	(31)
1-2 years	26	(21)	14	(24)	12	(18)
2-3 years	20	(16)	12	(20)	8	(12)
3-4 years	8	(6)	4	(7)	4	(6)
4-5 years	11	(9)	2	(3)	9	(13)
> 5years	22	(18)	9	(15)	13	(19)
Refractive error [*] [n (%)]						
Emmetropia (-0.50 - +0.50)	37	(30)	16	(28)	21	(31)
Hypermetropia (≥ +0.50)	59	(47)	32	(55)	27	(40)
Myopia (≤ -0.50)	29	(23)	10	(17)	19	(28)
Habitual correction [n (%)]						
Only multifocal correction	60	(48)	31	(52)	29	(43)
Only near correction	32	(25)	10	(17)	22	(33)
Distance and near correction	14	(11)	6	(10)	8	(12)
Multifocal and near correction	10	(8)	8	(14)	2	(3)
Only distance correction	4	(3)	2	(3)	2	(3)
Multifocal, distance and near correction	2	(2)	0	(0)	2	(3)
No optical correction	3	(2)	2	(3)	1	(2)
Multifocal and distance correction	1	(1)	0	(0)	1	(2)

[*] Missing data for 1 participant

sion. Variables with p values ≤ 0.25 were included in the logistic regression model.

Results
In all 129 (43%) of the 300 invited to the study, participated in the clinical examination. Three persons were excluded from the analysis due to missing data on HVA. The analysis was done for 126 subjects, 67 (53%) males and 59 (47%) females. Table 1 gives an overview of the time since last eye examination, type of optical correction and refractive errors for the subjects.

Vision and ocular examination
More than 50% of the 65-year-olds reported having had a vision examination the last two years. There was no statistically significant difference between males and females with regard to when they had their last vision examination (see Table 1). Nearly half of the participants (48%) reported having regular vision examinati-

ons, significantly more females than males (63% versus 36%, *p* = 0.004). The mean (±SD) time between vision examinations was 28 (±15) months. There was no significant difference between genders in the time between examinations. Fewer participants (35%) reported having regular ocular health examinations than regular vision examinations, and significantly fewer males than females (24% versus 48%, *p* < 0.008) reported having regular ocular health examinations. The mean (±SD) follow-up interval for ocular health examination was 32 (±19) months. Females reported significantly more frequent follow-up than males (28 months versus 42 months, *p* = 0.044).

Table 2 shows known ocular and systemic disease among the participants. More participants with known ocular disease reported having regular vision examinations (71% versus 43%, *p* = 0.022) and regular ocular health examinations (67% versus 28%, *p* = 0.001) than participants with no known ocular disease.

Table 2
Known ocular disease and known systemic disease which could affect vision

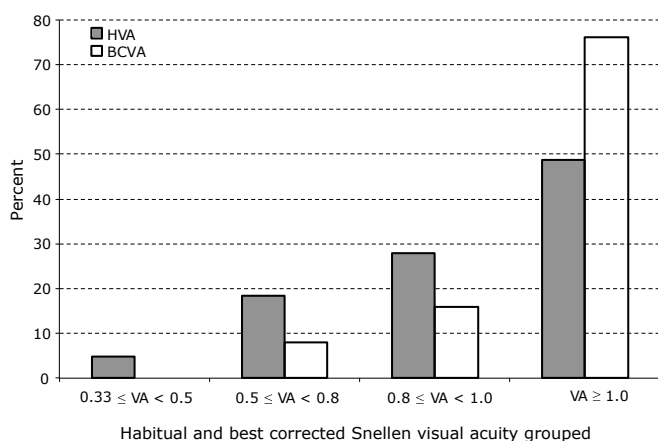|	All participants (*N* = 126)		Females (*n* = 59)		Males (*n* = 67)	
Known ocular disease [*n* (%)]						
Cataract	15	(12)	8	(14)	7	(10)
Glaucoma	4	(3)	1	(2)	3	(5)
AMD	2	(2)	2	(3)	0	(0)
Diabetic retinopathy	1	(1)	1	(2)	0	(0)
Other ocular disease	9	(7)	4	(7)	5	(8)
Known systemic disease [*n* (%)]						
Hypertension	43	(34)	18	(31)	25	(37)
Cardiovascular disease	23	(18)	9	(15)	14	(21)
Diabetes	10	(8)	4	(7)	6	(9)
Stroke	7	(6)	4	(7)	3	(5)

Figure 1. Distribution of habitual (HVA) and best corrected visual acuity (BCVA) grouped among Norwegian 65-year-olds

There was no significant difference with regard to reported regular vision examination and regular ocular health examination between participants with known systemic disease which may affect vision (diabetes/cardiovascular disease) and participants without known systemic disease which may affect vision.

Visual acuity
Mean (±SD) HVA was logMAR 0.04 (±0.14) (Snellen 1.0). Six participants (5%) did not meet the VA criterion for driving a car with up to eight passengers (Snellen < 0.5) with habitual correction. Mean BCVA (±SD) was logMAR -0.06 (±0.10) (Snellen 1.2). With their best correction all participants met the VA criterion for driving. Figure 1 shows HVA and BCVA for the participants.

Correctable visual impairment
Four out of the six participants who had correctable visual impairment (HVA Snellen < 0.5 which improved to BCVA ≥ 0.50) reported that it was more than 5 years since last vision examination. Table 3 shows the distribution of correctable visual impairment with regard to gender, time since last vision examination, habitual correction and refractive error.

Participants who reported that it was more than 5 years since their last vision examination had a significantly higher prevalence of correctable visual impairment than participants who reported a more recent vision examination, (67% versus 2%, *p* = 0.009), relative risk (RR) 9.1, CI [1.8, 48.4]. There was a non-statistically significant trend that participants who did not have an optical correction for distance vision or only used a near vision correction had a higher prevalence of correctable visual impairment than participants who wore an optical correction for distance. There was no statistically significant difference in prevalence of correctable visual impairment between the three refractive error groups. However, the participants with correctable visual impairment were found among participants with low refractive error (-0.50 D < SER < +0.50 D) or hyperopia (SER ≥ +0.50 D). There was no statistically significant difference in prevalence of correctable visual impairment between gender, participants with and without visual symptoms, participants with and without known ocular disease, or participants with and without known diabetes and/or cardiovascular disease. Table 4 shows the risk factors associated with visual impairment due to uncorrected refractive error. Long time (> 5 years) since last vision examination was the only independent predictor for correctable visual impairment, *OR* 2.7, 95% CI [1.0, 7.3], *p* = 0.046.

Clinically relevant undercorrected refractive error
In total 11 participants (9%) achieved improved VA with best optical correction by 1-5 lines compared with HVA. Eight of these participants (6% of the whole group) had clinically significant undercorrected refractive error, of these two had a 2 line improvement and six had an improvement of 3 lines or more. Participants with clinically significant undercorrected refractive error were found among persons with low refractive error (-0.50 D < SER < +0.50 D) or hyperopia (SER ≥ +0.50 D). Table 5 shows habitual correction and optimal correction for participants with clinically significant undercorrected refractive error. The habitual correction and optimal correction indicate that damaged lenses and/or poorly fitted spectacles may account for reduced vision in one of these patients.

Discussion

In all 5% of the 65-year-olds were unnecessarily visually impaired due to lack of optical correction for low refractive error and/or hyperopia. Additionally, damaged lenses and/or poorly fitted spectacles may have contributed to reduced vision. The proportion of correctable visual impairment is in accordance with large international population studies (Foran et al., 2002; Munoz et al., 2000; VanNewkirk et al., 2001).

None of the 65-year-olds were visually impaired with best correction. This is in line with the VIP study which showed that among persons < 65 years, the main cause of visual impairment is uncorrected refractive error and few are permanently visually impaired due to AMD, glaucoma, cataract, diabetes or other ocular disease (VanNewkirk et al., 2001). However, the lack of visual impairment in our study may be due to small sample size (n = 129) and low prevalence of visual impairment (0.5-1.5%) in this age group (Buch et al., 2004; Congdon et al. 2004).

In all 9% of the 65-year-olds achieved improved VA by 1 line or more with best correction compared with their HVA, and 6% had clinically significant undercorrected refractive error. This number is lower than that found in the BMES (Thiagalingam et al., 2002), even though the proportion of participants who achieved VA improvement of 3 lines or more was similar to the proportion found in the BMES. In the BMES more than half of persons who had clinically significant undercorrected refractive error were driving. Unfortunately our study did not include questions on driving, and we do not know how many of the 65-year-olds who were driving with inadequate vision. Nevertheless, it is disturbing that as many as 5% of 65-year-olds do not meet the VA criterion for driving, but would satisfy the VA criterion with the correct optical correction.

Long time (> 5 years) since last vision examination was the only independent predictor of correctable visual impairment. Participants who had not had a vision examination the last 5 years were 2.7 times more likely to have a correctable visual impairment than participants who reported a more recent vision examination. The odds are slightly higher than the odds reported in the BMES (Thiagalingam et al., 2002). There was a non-statistically significant trend that the prevalence of correctable visual impairment was higher among 65-year-olds who did not use a distance correction than among 65-year-olds who did. This trend is likely to have been significant if a larger sample had been examined. The persons with correctable visual impairment had low refractive error and/or hyperopia, however; there was no statistically significant association. Previous studies have shown that increasing age, hyperopia, no habitual distance correction and long time since last eye exam are associated with undercorrected refractive error (Liou et al., 1999; Thiagalingam et al., 2002). This supports the findings in our study.

Nearly 80% of the 65-year-olds had low refractive error (-0.50 - +0.50) or hyperopia (≥ +0.50). This is similar to the prevalence found in the BMES and BDES (Attebo et al., 1999; Wang et al., 1994). Increasing hyperopia and astigmatism with increasing age may explain the association between correctable visual impairment and long time since last vision examination (> 5 years.). Among the 65-year-olds in our study there was no association between visual symptoms and correctable visual impairment. Persons who experience a gradual increase in hyperopia or astigmatism may not be aware of the changes in vision or that an optical correction may improve their distance vision. Further,

Table 3
Prevalence of correctable visual impairment

| | Correctable visual impairment (VI) | | |
	No VI (n = 120)	Correctable VI (n = 6)	p*
Total [n (%)]	120 (95)	6 (5)	
Gender [n (%)]			
Males	63 (94)	4 (6)	0.684
Females	57 (97)	2 (3)	
Time since last vision examination [n (%)]			
< 2 years	64 (98)	1 (2)	
2-5 years	38 (97)	1 (3)	0.015
> 5 years	18 (82)	4 (18)	
Optical correction [n (%)]			
Distance and near correction	83 (98)	2 (2)	
Only distance correction	4 (100)	0 (0)	0.058
Only near correction	29 (91)	3 (9)	
No optical correction	2 (67)	1 (33)	
Refractive error [†] [n (%)]			
Emmetropia (-0.50 D - +0.50 D)	36 (97)	1 (3)	
Hypermetropia (≥ +0.50 D)	55 (93)	4 (7)	0.508
Myopia (≤ -0.50 D)	29 (100)	0 (0)	
Refractive error defined as in BMES[†,‡] [n (%)]			
Emmetropia (-1.0 D - +1.0 D)	66 (97)	2 (3)	
Hypermetropia (≥ +1.0 D)	35 (92)	3 (8)	0.434
Myopia (≤ -1.0 D)	19 (100)	0 (0)	

* Fisher's exact test
† Missing data for 1 participant
‡ Blue Mountains Eye Study (BMES)

some people may presume that reduced vision is a normal age-related decline, and some may avoid having a vision examination in fear of too poor eyesight for driving. Others may feel that their vision is good enough without spectacles or may not wish to wear spectacles for distance.

Less than 50% of the 65-year-olds reported having regular vision examinations, and only 30% had been for a vision examination within the last year. This is considerably less than in the VIP and SEE studies (Keeffe, Weih, McCarty, & Taylor, 2002; Orr,

Table 4
Risk factors for visual impairment due to uncorrected refractive error

| Risk factor [n (%)] | Persons with visual impairment (VI) | | OR (95% CI) | | | | | |
	No VI (n = 120)	Correctable VI (n = 6)	Unadjusted	p	Adjusted*	p	Multivariate model	p
Time since last vision examination > 5 years	18 (15)	4 (67)	3.4 [1.4, 8.2]	0.007	3.3 [1.4, 8.1]	0.008	2.7 [1.0, 7.3]	0.046
No correction/only near correction	31 (26)	4 (67)	5.6 [1.0, 32.2]	0.053	5.3 [0.9, 31.1]	0.065	2.3 [0.3, 16.7]	0.414
Known diabetes / cardiovascular disease	62 (52)	1 (17)	0.2 [0.0, 1.7]	0.131	0.2 [0.0, 1,60]	0.124		
Known ocular disease	23 (19)	1 (17)	0.8 [1.0, 7.6]	0.843	0.9 [0.1, 7.8]	0.895		

* Adjusted for gender

Table 5
Habitual and best optical correction for the participants who had correctable visual impairment and clinically significant undercorrected refractive error

| HVA (logMAR) in the better eye | Habitual distance correction | | | | Best distance correction | | |
	Corrective power OD	Corrective power OS	Optical correction	VA (logMAR)	Corrective power OD	Corrective power OS	VA (logMAR)
VA > 0.3*							
1			No	0.50	+0.50 -0.25 x 90	+1.25 -0.50 x 90	0.10
2			No	0.44	+2.25 DS	+1.50 -1.50 x 95	0.02
3			No	0.44	+2.00 DS	+2.00 -0.75	0.02
5	plano	plano	Multifocal	0.44	+0.25 -1.00 x 85	+0.50 DS	-0.06
6			No	0.40	Missing	Missing	-0.10
4			No	0.34	+0.50 -0.25 x 130	+1.00 -0.25 x 20	0.14
0.3 ≥ VA > 0.2†							
7	plano	plano	Multifocal	0.32	-0.25 -0.25 x 130	-0.75 DS	0.0
8	+1.25 -0.25 x 35	+1.25 -0.25 x 35	Multifocal	0.28	+1.25 -0.25 x 30	+1.25 -1.25 x 40	-0.14

* Snellen VA < 0.5
† Snellen 0.5 ≤ VA < 0.63

Barrón, Schein, Rubin, & West, 1999). This could be related to guidelines and organization of eye care services. In the USA the American Academy of Ophthalmology recommends that elderly people are examined by an ophthalmologist annually/biannually (American Academy of Ophthalmology Preferred Practice Patterns Committee, 2005). In Australia eye examinations are fully/partly covered by the Medicare Australia (Keeffe et al., 2002). There are no official guidelines for examination of vision and ocular health in the elderly in Norway, but the Norwegian Association of Optometrists' clinical guidelines recommend Norwegian optometrists to examine persons > 65 years annually (NOF, 2005). In Norway examination by an ophthalmologist requires referral by a medical doctor or optometrist. Examination by medical doctors and ophthalmologists are covered by Folketrygden (national insurance system), whereas expenses for examinations by optometrists must be covered in full by the patient.

The proportion of participants who reported more than 5 years since last vision examination was similar to the rate in the VIP study. In the VIP males, persons with no known ocular disease, and persons with undercorrected refractive error were more likely not to have had an eye examination during the last 5 years (Keeffe et al., 2002). In our study long time since last vision examination was the only independent predictor of correctable visual impairment. The VIP also showed that among persons likely to benefit from having an eye examination, persons with undercorrected refractive error where less likely to have had an eye examination within the last 2-5 years when compared to the general population. (Bylsma, Le, Mukesh, Taylor, & McCarty, 2004).

It is important to reach elderly people who are not having regular eye examinations. Unnecessary visual impairment can be prevented by regular eye examination, correction of refractive error and early detection of sight-threatening ocular disease. Health promotion campaigns and eye surveys can increase utilization of eye care services and promote regular eye examination (Fong et al., 2009; Muller, Keeffe, & Taylor, 2007).

The present study has limitations. The sample is small ($n = 126$) and the power of the study is too low to assess the general prevalence of visual impairment. The participation rate is moderate (43%), and selection bias may overestimate the proportion of persons with correctable visual impairment. Information bias may influence the results. The information about eye examinations is based on patient self-report and is influenced by patient recall, telescoping and social acceptance (Beckles et al., 2007; Fowles, Rosheim, Fowler, Craft, & Arrichiello, 1999).

Correctable visual impairment was found in 5% of 65-year-olds. Regular eye examination and correction of low refractive errors and hyperopia can prevent unnecessary visual impairment in the elderly.

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