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HEALTHY AGING RESEARCH

Falling in older adults with or without visual impairment in community dwellings

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Abstract

Background: The aims of this work were to study visual impairment among community-dwelling older adults and assess home environments of the elderly with and without visual impairment who had fallen.

Methods: Two hundred seventy-nine older adults were recruited from three community day centers in Hong Kong. Visual acuity and self-reported falls over the preceding 12 months were documented. For those who had fallen indoors, 37 home visits were conducted.

Results: Of the elderly cohort, 15.4% were found to have impaired vision and 29.6% had fallen over the preceding 12 months. While the prevalence of falling in the elderly with impaired vision was similar to those without visual impairment, the visually impaired adults walked more slowly and were not able to reach as far in forward-reaching tests. In the homes of those with visual impairment who had fallen, there was significantly lower light intensity, a greater number of hazards in home hallways and increased use of floor mats compared to those without vision impairments who had fallen.

Conclusions: Older adults with visual impairment did not show a higher incidence of falls, but home safety awareness is important to reduce falls.

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Introduction

Visual impairment can have a significant effect on an individual's functioning and their interaction with their physical and social environments. As visual impairment is more prevalent with increasing age [1, 2], more people are at risk of having impaired vision in the aging population. In Hong Kong, 41.3% of the population 60 years of age or older were found to have at least one eye with visual acuity less than 20/60 and 19.5% had visual acuity less than 20/60 in both eyes (i.e., the better eye < 20/60) [2].

Maculopathy (31.7%), cataract (29.54%), retinal degeneration (15.7%), and retinitis pigmentosa (4.45%) were the major causes of visual impairment in the elderly population [3].

Visual impairment has been identified either as an independent risk factor or as being associated with an increased risk of falling [1, 4-8]. Forty percent of individuals with low visual acuity were found to have fallen in one year [4], which is higher than the reported annual rate of falls in the older population living in community dwellings [5].

Furthermore, the risk of hip fractures in women with poor or moderately impaired vision was doubled [9]. Several studies published in the last 15 years have also shown that impaired vision adversely affects postural stability and increases the risk of falling in older people [6, 10]. People with visual impairment may fail to see, over-correct in stepping over environmental hazards, or have difficulty taking corrective action after a stumble [6]. There have not yet been any studies assessing the differences between the home environments of older adults with or without visual impairment. Therefore, in this study, we aimed first to identify the prevalence of visual impairment among community-dwelling older adults and second, to assess the indoor home environments among fallers with or without visual impairment.

Methods

Participants

Two hundred and seventy-nine older adults aged 65 years or above were recruited using convenience sampling (Fig. 1). They were enrolled on three separate occasions in a community eye care project for elderly people in day activity centers, in three different but representative geographic districts in Hong Kong.

Participants must have been residing in community dwellings; those who lived in public and private old age homes or elderly hostels were excluded from the study. Also excluded were those who had communication difficulties and those who had scores in the Cantonese Mini-Mental State Examination (MMSE) [11] that were lower than the cut-off scores, according to their educational level (a score of 22 for those who had received over 2 years of education, 20 for those who had received 0.5 - 2 years of education, and 18 for those who were illiterate) [12]. These cutoff scores were used because it has been reported that those who failed the MMSE test were predicted to have a reduced ability, i.e., 74%, to recall a fall in the previous 12 months [13]. Informed and verbal consent was sought from all participants before data collection.

Procedures

During the screening, face-to-face interviews and baseline assessments were performed and were recorded along with demographic information.

Visual assessment

According to the International Classification of Diseases, 10th revision (ICD-10), visual impairment caused by uncorrected or inadequately corrected refractive errors is defined as visual acuity of less than 20/60 (6/18) in the best eye [14]. In this study, the visual acuity of participants was assessed by four registered optometrists, using a Snellen chart [15].

Fall risk assessment

A fall was defined as an event resulting in a person coming to rest unintentionally on the ground or another lower level [16]. Four final-year occupational therapy students were trained to be responsible for the assessments, including measurement of body mass index (BMI), the timed up and go test (TUGT) [17], and the functional reach test (FRT) [18]. All participants were asked to recall the incidence of falls over the 12 months preceding their attendance at the assessment.

Home visits were conducted by the four occupational therapy students from the Hong Kong Polytechnic University during the course of one month for those participants who reported falls during the interview. The purpose of the home visits was to identify environmental hazards and lighting conditions associated with the falls. The environmental evaluation included the use of the Westmead Home Safety Assessment (WeHSA), which is a systematic assessment of a range of potential hazards [19], and light intensity (Lux), measured using a light meter. During the measurements, the light meter was placed at eye level 30 cm from the client who was either sitting on their own bed or a chair in the living room, standing in front of the water closet or bathtub, or near the keyhole of the main entrance with the light on or off during the daytime.

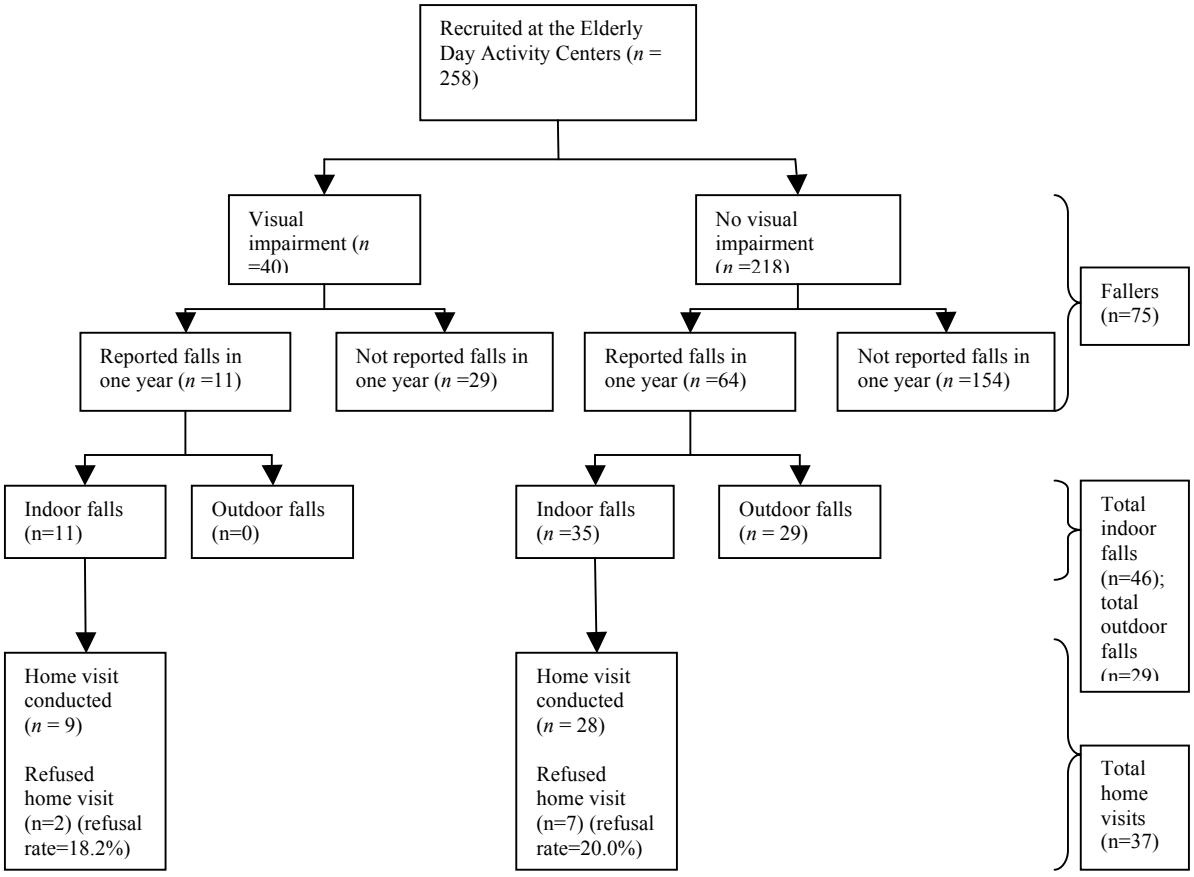

Figure 1. Flowchart of the criteria by which the participants were assigned to their respective groups

Statistical analysis

Data were analyzed with SPSS (version 19.0). Demographic data, with percentage and range for those elderly with and without visual impairment, were reported. T-tests, Mann-Whitney U tests, and chi-squared tests were conducted to compare the demographic and functional parameters, and to analyze the differences in environmental factors between the falling elderly with and without visual impairment.

Results

Patient characteristics

The cohort's baseline characteristics are summarized in Table 1. A total of 279 elderly subjects aged 65 or above were recruited on three occasions in 1 year. Eighteen participants were excluded from the study after recruitment because their total scores in the MMSE were below the cut-off for their educational level. Two hundred and fifty-eight participants were entered into the final analysis. The mean age (SD) of participants was 77.2 (6.2) years, with the majority of the participants classified as "young old" (65-75 years-old; n=101) and "old old" (76-85 years-old; n=126). Forty-five participants (17.4%) were male

and 213 (82.6%) were female. While 34.5% of participants lived alone, 23.3% lived with a spouse in community dwellings, with 71.2% able to take care of themselves in terms of light household duties and 53.9% able to perform heavy household tasks. The five most commonly diagnosed co-morbidities were high blood pressure (54.2%), eye disease (23.5%), diabetes mellitus (21.5%), arthritis (17.3%), and cardiac disease (15.0%). In general, they were good walkers and 77.1% did not require walking aids.

Seventy-five (29.6%) participants reported one or more falls in the 12 months preceding the assessment. The one-year prevalence of falls (people with at least one fall in the previous 12 months) was the number of participants with a history of falls (1 or more) in the previous 12 months, divided by the total number of participants, which is 75/258 or 29.1%. Forty-six of the falls (61.3%) occurred indoors while 29 (38.7%) occurred outdoors.

Table 1. Baseline characteristics and comparison of demographic/functional parameters between participants with or without visual impairment

Characteristics	All Participants (n=258)	Elderly with visual impairment (n= 40)	elderly without Visual impairment (n=218)	#*p* value
Gender, n (%)	258 (100.0)	40 (100.0)	218 (100)	0.659
Male	45 (17.4)	6 (15.0)	39 (17.9)	
Female	213 (82.6)	34 (85.0)	179 (82.1)	
Age, mean ±SD	77.2±6.2	79.8±6.0	76.7±6.1	0.005*
Age range, n (%)	258 (100.0)	40 (100.0)	218 (100)	
Young-old	100 (38.8)	9 (22.5)	91 (41.7)	0.022*
Middle-old	126 (48.8)	22(55.0)	104 (47.7)	0.397
Old-old	32 (12.4)	9 (22.5)	23 (10.6)	0.035*
Education, n (%)	258 (100.0)	40 (100.0)	218 (100.0)	
No formal education	92 (35.7)	17 (42.5)	75 (34.4)	0.327
Primary	127 (49.2)	21 (52.5)	106 (48.6)	0.653
Secondary	33 (12.8)	2 (5.0)	31 (14.2)	0.109
Tertiary or above	6 (2.3)	0 (0)	6 (2.8)	0.289
Living environment, n (%)	258 (100.0)	40 (100)	218 (100)	
Public housing estate	132 (51.2)	24 (60.0)	108 (49.5)	0.225
Housing ownership scheme	11 (4.3)	1 (2.5)	10 (4.6)	0.549
Private housing	106 (41.1)	13 (32.5)	93 (42.7)	0.231
Others	9 (3.5)	2 (5.0)	7 (3.2)	0.572
Persons living with, n (%)	260 (100.0)	40 (100.0)	218(100.0)	
Alone	89 (34.5)	12 (30.0)	77 (35.3)	0.516
Family members ≧ 65 years	60 (23.3)	10 (25.0)	50 (22.9)	0.777
Family members < 65 years	105 (40.6)	18(45.0)	87(39.9)	
Domestic helper/ maid	4 (1.6)	0(0)	4(1.8)	
Dependency of light household duties, n (%)	258 (100.0)	40 (100.0)	218 (100.0)	0.170
Takes care of oneself	183 (71.2)	32 (80.0)	151 (69.3)	
With family member or domestic aide	75 (29.1)	8 (20.0)	67 (30.7)	
Dependency of heavy household duties, n (%)	260 (100.0)	40 (100.0)	218 (100.0)	0.877
Takes care of oneself	139 (53.9)	22 (55.0)	117 (53.7)	
By couple or domestic aide	119 (46.1)	18 (45.0)	101 (46.3)	
Indoor mobility aid, n (%)	258 (100.0)	40 (100.0)	218 (100.0)	0.063
None	238 (92.2)	34 (85.0)	204 (93.6)	
Walking aids	20 (7.8)	6 (15.0)	14 (6.4)	
Outdoor mobility aid, n (%)	258 (100.0)	40 (100.0)	218 (100.0)	0.047*
None	199 (77.1)	26 (65.0)	173 (79.4)	
Walking aids	59 (22.9)	14 (35.0)	45 (20.6)	

Time up and go test (TUGT), mean ±SD	13.4 ± 5.5	17.2 ± 9.2	12.7 ± 4.2	0.001**
Forward reaching (cm), mean ±SD	20.0 ± 7.4	17.0 ± 8.2	20.6 ± 7.2	0.005*
Body mass index (BMI), mean ±SD	23.8 ± 3.7	23.7±3.4	23.9±3.8	0.714
Mini-Mental Status Examination (MMSE), mean ±SD	25.5 ± 3.2	24.8 ±3.1	25.7±3.2	0.071
Visual acuity (Left), mean ±SD	2.8±1.4	1.13 ± 0.7	3.15 ± 1.3	
Visual acuity (right), mean ±SD	3.1±1.3	1.23 ± 0.7	3.5 ± 1.0	
Distant vision (Left), n (%)	257 (98.8)	39 (97.5)	218 (100)	
Normal	11 (4.2)	0 (0.0)	11 (5.0)	
Inadequate	246 (94.6)	39 (97.5)	207 (95.0)	
Distant vision (Right), n (%)	257 (98.8)	39 (97.5)	218 (100)	
Normal	11 (4.2)	0 (0.0)	11 (5.0)	
Inadequate	246 (94.6)	39 (97.5)	207 (95.0)	
Near vision (Left), n (%)	255 (98.1)	39 (97.5)	216 (99.1)	
Normal	137 (52.7)	14 (35.0)	123 (56.4)	
Inadequate	118 (45.4)	25 (62.5)	93 (42.7)	
Near vision (Right), n (%)	257 (98.8)	39 (97.5)	218 (100)	
Normal	153 (58.8)	13 (32.5)	140 (64.2)	
Inadequate	104 (40.0)	26 (65.0)	78 (35.8)	
Presence of chronic diseases, n (%)	259 (99.6)	40 (100.0)	218 (100.0)	
Yes	217 (83.5)	36 (90.0)	179 (82.1)	0.239
No	42 (16.2)	4 (10)	39 (17.9)	
Co-morbidities, n (%)				
Stroke	9 (3.5)	2 (5.0)	7 (3.2)	0.576
Dementia	1 (0.4)	0 (0)	1 (0.5)	0.668
Osteoporosis	24 (9.2)	8 (20.0)	15 (6.9)	0.008**
Arthritis	45 (17.3)	10 (25.0)	33 (15.2)	0.128
Parkinson's disease	1 (0.4)	0 (0)	1 (0.5)	0.668
High blood pressure	141 (54.2)	27 (67.5)	112 (51.6)	0.064
Diabetes mellitus	56 (21.5)	10 (25.0)	44 (20.2)	0.501
Eye disease	61 (23.5)	13 (32.5)	47 (21.6)	0.137
Low blood pressure	5 (1.9)	1 (2.5)	4 (1.8)	0.783
Chronic chest disease	6 (2.3)	0 (0)	6 (2.8)	0.288
Cardiac disease	39 (15.0)	7 (17.5)	32 (14.7)	0.656
Depression	8 (3.1)	0 (0)	8 (3.7)	0.218
Cancer	2 (0.8)	1 (2.5)	1 (0.5)	0.178
Previous upper limb fracture	1 (0.4)	0 (0)	1 (0.5)	0.668
Previous lower limb fracture	7 (2.7)	1 (2.5)	5 (2.3)	0.940
Low back pain	14 (5.4)	0 (0)	13 (6.0)	0.113
Average number of diseases, *mean ±SD*	1.62 ± 1.2	1.98 ± 1.2	1.52 ± 1.2	0.027*
Number of drugs, n (%)	260 (100.0)	40 (100.0)	218 (100.0)	
None	63 (24.2)	6 (15)	57 (26.1)	0.132
1-3 types	166 (63.8)	25 (62.5)	139 (63.8)	0.879
4 types ≧	31 (11.9)	9 (22.5)	22 (10.1)	0.027*
Receiving social services, n (%)	260 (100.0)	40 (100.0)	218 (100.0)	
Day activity center	51 (19.6)	10(25.0)	39(17.9)	0.293
Elderly center	241 (92.7)	38(95.0)	201(92.2)	0.534
Enhanced home care service	27 (10.4)	5(12.5)	22(10.1)	0.648
Receiving medical service, n (%)	206 (79.2)	34(85.0)	170(78.0)	0.317
Receiving active rehabilitation service, n (%)	10 (3.8)	2(5.0)	8(3.7)	0.689
Prevalence of falls within 1 year, n (%)	258 (100.0)	40 (100.0)	218 (100.0)	
Yes	75 (29.1)	11(27.5)	64(29.4)	0.812
No	183 (70.9)	29 (72.5)	154 (70.6)	

Comparison performance between elderly participants with and without visual impairment.
*$p < 0.05$; **$p < 0.01$

Forty participants (15.4%) were identified as having a visual impairment. The prevalence of visual impairment (the number of participants with visual impairment divided by the total number of participants) was 40/258, equal to 15.5%. The prevalence of falls in the elderly with visual impairment was 27.5% (11/40), and the prevalence of falls in the elderly without visual impairment was 29.4% (64/218).

The demographic and functional parameters of those with (n=40) and without visual impairment (n= 218) are presented in Table 1. Between these groups, there were significant differences in age (p=0.005), osteoporosis (p=0.008), average number of diseases (p=0.027), the use of four or more drugs (p=0.027), and use of mobility aids in outdoor activities (p=0.047). In addition, people with visual impairment were older (0.005), walked slower in the TUGT (p=0.001), and reached less in the FRT (p=0.005) than those without visual impairment.

Home visits

Forty-six participants who had fallen indoors in the previous 12 months were selected for home visits. Nine of those refused visits and therefore a total of 37 participants were visited at their homes. Among them, 9 (24.3%) had visual impairments.

The lighting conditions and home environments of participants with and without visual impairment who had fallen indoors were assessed using a light meter and the WeHSA, respectively, during the home visits, and these results are summarized in Table 2. For those with visual impairment who had fallen (n=9), homes were dimmer in the bedroom (p=0.046), water closet (p=0.014), and bathtub (p=0.027) than those without visual impairment who had fallen at home (n=28).

The results of the WeHSA showed that those with a visual impairment who had fallen indoors had more hazards in areas of traffic ways within the home (p=0.013), and these hazards included floors and floor coverings, floor mats, light switches, space (obstacles, proximity, color contrasts), mobility aids, doorways, ramps, stairs/steps, and handrails. Evaluation of the top ten hazards showed that there were significantly more 'floor mat' hazards (p=0.005) for those with visual impairments who had fallen, than those without (Table 3).

Table 2. Light intensity of the home environments of participants who fell indoors

Light intensities in commonly used area (Lux), mean ± SD	Indoor fallers with visual impairment (n=9)	Indoor fallers without visual impairment (n=28)	*p* value	Recommended illumination level (Lux) (CIBSE, 2002)[#]
Keyhole	14.8 ± 18.5	62.0 ± 97.3	0.061	
Living room				150
With light on	196.6 ± 275.5	249.4 ± 232.1	0.210	
With light off	135.8 ± 232.1	149.5 ± 223.9	0.749	
Bedroom				50
With light on	103.4 ± 119.7	187.4 ± 133.2	0.046*	
With light off	57.5 ± 86.8	108.0 ± 111.7	0.219	
Water closet				100
With light on	86.1 ± 49.3	176.5 ± 101.0	0.014*	
With light off	44.7 ± 61.6	66.7 ± 97.3	0.749	
Bathtub				100
With light on	72.4 ± 59.8	182.2 ± 169.3	0.027*	
With light off	29.4 ± 66.0	89.4 ± 167.3	0.941	

*$p < 0.05$; **$p < 0.01$ [#]CIBSE - Chartered Institution of Building Services Engineers

Table 3. Westmead Home Safety Assessment results for participants who fell indoors

WeHSA[#] areas	Indoor fallers with visual impairment (n=9) *Mean ± SD*	Indoor fallers without visual impairment (n=28) *Mean ± SD*	*p* value
External traffic ways	0.2 ± 0.4	0.6 ± 1.0	0.355
General	0.7 ± 0.9	1.3 ± 1.5	0.275
Internal traffic ways	1.7 ± 1.0	0.7 ± 1.2	0.013*
Living area furnishings	0.4 ± 0.7	0.2 ± 0.4	0.256
Seating	0.2 ± 0.7	0.3 ± 0.7	0.746
Bedroom	0.2 ± 0.4	0.7 ± 1.0	0.165
Footwear	0.3 ± 0.5	0.2 ± 0.4	0.491
Bathroom	1.8 ± 1.9	1.6 ± 1.8	0.899
Toilet	1.1 ± 0.8	1.0 ± 1.4	0.272
Kitchen	0.3 ± 0.5	0.4 ± 0.7	0.928
Laundry	0.1 ± 0.3	0.0 ± 0.0	0.146
Medication	0.1 ± 0.3	0.1 ± 0.2	0.582
Safety call system	0.2 ± 0.4	0.1 ± 0.2	0.183
Average total score	7.4 ± 3.7	7.2 ± 5.2	0.443
WeHSA Top 10 hazards			
Slippery surfaces	1.2±1.8	1.6±1.5	0.398
Obstacles in traffic ways	0.4±0.9	0.3±0.7	0.631
Poor illumination	0.9±1.1	0.6±1.2	0.356
Floor mats	1.1±1.3	0.2±0.4	0.005*
Footwear	0.3±0.5	0.2±0.4	0.491
Ladder/chair used to climb	0.2±0.4	0.3±0.6	1.000
Bath	1.7±1.9	1.6±1.8	0.859
Uneven pathways	0.0±0.0	0.1±0.3	0.321
Cords on floor	0.0±0.0	0.2 ±0.4	0.144
Steps/stair railing	0.1±0.3	0.4±0.5	0.107
Average total score	6.0 ± 3.7	5.4 ± 4.0	0.457

[#]WeHSA = Westmead Home Safety Assessment (Ref: Clemson L. Westmead Home Safety Assessment (WEHSA). Australia: Co-ordinates Publications; 1997)

Discussion

Some studies have indicated that people with visual impairment fall more frequently than those with normal eyesight [21-25]. However, in our study, the prevalence of falls in the elderly both with and without visual impairment was similar. Older adults with visual impairment have difficulty seeing the environment clearly. As such, they tend to walk slowly to reduce the risk of fall and tend to use mobility aids for safety [26].

Home hazards represent a tangible risk of falling for older adults [27], especially if the older adult presents with other risk factors for falling. In this study, those with vision impairment who had fallen presented with increased home hazards in internal traffic ways compared to those without vision impairment, as evaluated by the investigators. Due to poor vision, the elderly may not be aware of the worn edges, slippery surfaces, or mobility of floor mats unless a fall happens. Visually-impaired older adults also presented with significantly lower light intensity in the bedroom, water closet, and bathtub areas, and

among these areas, the levels of light in the water closet and bathtub areas were also lower than illumination standards [28]. This could be due to their habits or attempts to reduce the glare associated with lighting. For individuals with cataracts, increased illuminance levels may have an adverse effect on their visual performance [29]. To overcome this light-dark adaptation among the elderly with visual impairments and to minimize glare, some design factors, such as high contrast color-coding of corners, potential obstacles, grab bars, and improvement of the uniformity of illumination inside the house are important [30].

The decline in older adults' functional capacity requires an increase in their coping skills to allow them to continue participation in their daily lives. As such, there is a need for an improved fit between the elderly person and their environment, as the environment may affect their ability to participate in daily activities and a less-than-ideal environment may hinder engagement in activities. From this study, older adults with vision impairment were found to have more hazards in their walkways, increasing their already heightened risk for falling due to low vision. Furthermore, the luminance level was also less than ideal, which may add to the functional burden within their home environment, especially pertaining to visual tasks. Therefore, home safety education and environmental modifications should be priorities in raising awareness of environmental hazards in the community and at homes for elderly people with visual impairment, which have been shown to be effective in reducing falls [31].

Limitations

This study had several limitations. The sample was drawn from three elderly day centers by convenience sampling and therefore the results may not be generalized to the whole population of older adults in community dwellings. As this is a retrospective cohort study, information was collected through self-reported interviews, and in effect, data are dependent on the individual's ability to recall falls over various time intervals. This may affect the accuracy of the fall history data reported. In addition, the elderly participants who failed the MMSE test were excluded from this study, as cognitive impairment has been found to be a significant risk factor for falls [5]. This baseline may exclude people who fell but did not accurately recall their falling history. In this study the cause of the older adults' vision impairment is not indicated, and other vision functions, such as contrast sensitivity or depth perception, which have been found to be more important visual risk factors for falls, were not assessed [26, 32]. In addition, there was no indication of the type of lighting used by the older adults in this study, which could potentially provide more insight than the level of light intensity.

Conclusions

Although visual impairment may not be prevalent in the community-dwelling elderly, it may go unnoticed until the older adult presents with other issues, such as an injurious fall. It is important to increase the community's awareness of home safety and environmental modifications for older adults, including the provision of appropriate lighting to facilitate their engagement in daily activities in and outside of their homes, and to reduce falls.

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