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Locations, Circumstances, and Outcomes of Falls in Patients with Glaucoma

Ayodeji E. Sotimehin¹, Andrea V. Yonge¹, Aleksandra Mihailovic^{1,2}, Sheila K. West^{1,2}, David S. Friedman^{1,2}, Laura N. Gitlin³, and Pradeep Y. Ramulu^{1,2}

¹The Wilmer Eye Institute, Johns Hopkins University School of Medicine; Baltimore, Maryland

²The Dana Center for Preventive Ophthalmology, Johns Hopkins University; Baltimore, MD

³College of Nursing and Health Professions, Drexel University; Philadelphia, Pennsylvania

Abstract

Purpose—To characterize the locations, circumstances, and outcomes of falls in patients with varying degrees of glaucoma.

Design—Prospective cohort study

Methods—Patients with suspected or diagnosed glaucoma completed monthly calendars reporting falls. After each fall, a 30-item questionnaire was administered to determine fall location, circumstances, and injury. Mean deviation on visual field (VF) testing was used to categorize glaucoma severity.

Main Outcome Measures—Fall locations, circumstances, and outcomes.

Results—One-hundred forty-two patients experienced 330 falls. Falls were most likely to occur in/around the home (71%), and this likelihood did not vary significantly with severity of VF damage ($p > 0.2$). The most commonly cited fall circumstances were tripping, (43.6%), slipping (31.3%), uneven flooring (23.5%), and poor vision (15.9%). The circumstances related to falls did not vary by severity of VF damage ($p > 0.2$) except for poor vision, which was more frequently cited in individuals with more advanced VF damage ($p = 0.001$). Forty-three percent of falls resulted in some injury; and the likelihood of injury did not vary by severity of VF loss ($p = 0.60$) or any other factor except floor type and number of comorbidities ($p < 0.05$ for all). Falls in persons with more severe glaucoma were more likely to result in a fracture (9.4%) or an ER visit (18.8%), though these associations did not persist in multivariable models ($p > 0.5$ for all).

Corresponding Author: Pradeep Y. Ramulu MD MHS PhD, Address: 600 N. Wolfe Street, Baltimore, MD 21287, Phone: 410-955-6052, pramulu@jhmi.edu.

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DISCLOSURES

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Conclusions—Glaucoma patients fall mostly in/around the home and demonstrate similar fall circumstances across the spectrum of disease severity, suggesting that current fall-prevention-interventions, particularly those emphasizing home modification, may be an adequate starting point to prevent falls in this high-risk-group.

INTRODUCTION

Falls are a significant cause of morbidity and mortality in older adults, affecting one third of adults over the age of 65.¹ Up to 20% of falls result in serious injury such as fracture or head trauma,² leading to decreased independence, increased fear of falling,³ and billions of dollars in healthcare expenditures.⁴ Poor vision is widely accepted as a significant risk factor for falls, with many fall interventions including either an objective or subjective measure of visual ability.⁵ Among the different forms of visual impairment, visual field (VF) loss may be the most significant.⁶ Binocular VF loss has been cited as the leading visual risk factor for falls and fractures among older community-dwelling populations^{7,8} and several studies have found a higher rate of falls in persons with glaucoma,^{9–12} indicating that older adults with glaucoma may represent a high-risk group for falls and should be targeted for fall interventions.

One approach to preventing falls and fall-related injuries is to identify the most common locations and circumstances in which falls occur and then utilize such information to guide behavioral and environmental interventions.^{13–17} Indeed, the efficacy of home safety interventions in reducing the risk of falls attests to the importance of environmental factors.^{18–20} Additionally, home safety interventions and similar interventions involving modification of the home environment are of particular interest to persons with glaucoma given that VF loss that occurs is currently irreversible. However, it is unclear if persons with glaucoma share the same fall circumstances as the general elderly population, or if the circumstances of falls differ in patients with varying degrees of VF damage.

The purpose of this study, therefore, is to examine which circumstances and locations are more commonly associated with falls at more advanced levels of VF damage, and to determine whether the degree of VF damage influences the risk of injury associated with a fall. These questions were answered using data from a large, prospective assessment of falls in older adults with varying degrees of glaucoma. Location, circumstances, and injuries resulting from falls were assessed within weeks of prospectively-reported falls. We hypothesized that certain environmental conditions such as changes in elevation, uneven walking surfaces, and physical obstructions would be more frequently associated with falls in persons with greater VF damage. By increasing our understanding of the locations, activities, behaviors, and other circumstances that contribute to falls in persons with VF loss, we will be better able to tailor interventions that can decrease falls and falls-related injury in this high-risk population.

METHODS

The Falls in Glaucoma Study (FIGS) protocol was approved by the Johns Hopkins Institutional Review Board, and all study participants signed written informed consent authorizing all study procedures. All procedures were approved prior to study initiation.

Study participants

Study participants were recruited from the Johns Hopkins Wilmer Eye Institute glaucoma clinic between September 2013 and March 2015. Study participants were eligible if they: (1) were ≥ 57 years of age, (2) had a chart diagnosis or suspicion of primary open angle glaucoma, primary angle closure glaucoma, pseudoexfoliation glaucoma, or pigmentary glaucoma, and (3) were able to perform VF testing. Study participants were excluded if they had worse than 20/40 vision in either eye due to any disease other than glaucoma, were confined to a bed or wheelchair, or lived >60 miles from Baltimore. Analysis was limited to participants who fell and completed a follow-up questionnaire describing their fall circumstances.

Visual assessment and classification

All participants underwent a comprehensive baseline examination to assess visual function, including visual acuity (VA), and Humphrey 24-2 VFs performed on a HFA-2 machine (Carl Zeiss Meditec, Dublin, CA). Better-eye VA was analyzed as the logarithm of the minimum angle of resolution (logMAR).²¹ Average sensitivity (in dB) across VF test locations was calculated for the integrated VF (IVF), which was used as the primary metric for VF loss given that mean deviation (MD) values vary for the same sensitivity across different age groups.^{22,23} Points from the right and left eye VFs were integrated using the maximum sensitivity between the two eyes. Exponentiated sensitivity values were averaged to calculate a mean value for the integrated field, which was then re-logged to produce the mean sensitivity of the integrated field in decibel (dB) units. To determine cut points for classifying glaucoma severity using average IVF sensitivity, a regression analysis was first performed for average IVF sensitivity and better-eye MD for all patients with VF data ($n=241$) to match IVF sensitivities with MD values. IVF sensitivity cutoffs were then set at >28 dB, 23–28 dB, or <23 dB, respectively, corresponding to Hodapp-Anderson-Parrish values of MD -6 dB, -6 to -12 dB, and -12 dB.²⁴ Normal mean IVF sensitivity in older patients is roughly 31 dB.

Characterization of covariates

All participants were asked about sociodemographic characteristics, current medications, and comorbid medical conditions from a list of 15 diseases (arthritis, broken or fractured hip, back problems, history of heart attack, history of angina/chest pain, congestive heart failure, peripheral vascular disease, high blood pressure, diabetes, emphysema, asthma, stroke, Parkinson's disease, cancer other than the skin cancer, and history of vertigo or Meniere's disease).²⁵ Polypharmacy was defined as ≥ 5 systemic prescription medications.²⁶ Depressive symptoms were assessed using the Geriatric Depression Scale, with scores of greater than 6/15 classified as positive.²⁷ Cognitive status was evaluated using the Mini-Mental State Examination for the visually impaired (MMSE-blind).²⁸

Identification of falls and fall-related circumstances

All participants filled out up to 33 months of falls calendars (study period: September 2013–May 2016) using a paper calendar, and reported their falls via email or mail. Follow-up calls were made weekly to those not returning calendars to optimize collection of all fall events. Falls were defined for participants prior to calendar distribution as “any fall, slip, or trip in which you lose your balance and land on the floor or ground or at a lower level.”²⁹ Participants were also shown an instructional video showing events that would be considered as falls, as well as other events that would not constitute a fall, during their baseline clinic visit.³⁰ For each reported fall, a 30-item falls follow-up questionnaire was administered over the phone to the participant to provide data on fall location, circumstances, injury, and treatment sought [Appendix – FFUQ]. Participants also provided narratives of falls in their own words limited to one sentence.

Assessment of the study population representativeness

Representativeness of our recruited sample was judged in relation to a sample of patients meant to reflect the full group of study-eligible patients from our clinic population. Over one clinic week, 97% of all patients (n=258) judged to be study-eligible provided oral consent and completed a short set of questions to capture their age, race, gender, use of an assistive device, and self-reported history of falls in the past year. Mean deviation was analyzed for all study-eligible patients during the same week. Recruited participants had similar age, race, gender and mean deviation of a better eye to that of the study-eligible sample, though participants were more likely to have reported use of an assistive device (35 vs 13%, $p<0.001$) and to report a fall within the past year (42 vs 23%, $p<0.001$), suggesting preferential recruitment of subjects at high risk of falling.

Statistical analyses

Descriptive analyses were conducted using falls data obtained during the study. Only the first 10 falls per patient were included to prevent overrepresentation of two patients who fell many times (11 and 38 falls). Chi-squared analyses and one-way ANOVA tests were used to evaluate differences in sociodemographic variables and circumstances of falls across the three categories of VF loss. Data were also analyzed using injurious falls only. Along previously published guidelines,³¹ severity of injury was classified as: 1) no injury; 2) mild injury, which included pain, bruising, swelling, scrape, or bleeding; 3) moderate injury, which included sprained ligament/tendon, joint dislocation, pulled muscle, or stitches; and 4) severe injury, which included fracture or hospital admission.

Factors which contributed to any fall, as well as the subset of falls resulting in any injury, were analyzed for the full study population and analyzed to determine if they were more/less frequent in participants with more severe VF damage. Regression models incorporating generalized estimating equations (GEE) were used to determine factors associated with a higher likelihood of injury; multiple falls per patient were included in these models to account for correlations between falls occurring in the same individual. Age, sex, and race were included as fixed covariates, as were any variables associated with the injury outcome measure of interest in univariate analysis. Models incorporating GEE were also used to determine if individual contributing factors were more likely to be cited as a contributing

factor for a fall in study participants with more severe VF damage. All data were analyzed using Stata 14.0 (StataCorp LP, College Station, TX).

RESULTS

Characteristics of patient sample

The mean baseline age was 71.3 years, and approximately half were male (45.1%). Average duration of follow-up was 24.5 months (range=14.9 to 32.7 months) with a 94% response rate for submitting fall calendars. Subjects with normal/near normal VFs, mild-moderate VF damage, and severity VF loss differed with regards to age and race, but no other demographic or health features (Table 1).

Total falls and injurious falls by location

One-hundred forty-two study participants experienced a total of 330 falls with a median of 2 (IQR = 1 to 3) (Table 2). One-hundred and forty-three falls (43.3%) resulted in some injury, including 15 falls (4.5%) resulting in a fracture and 11 falls (3.3%) resulting in a hospital admission. Falls were split evenly between indoor and outdoor locations (166/330 and 164/330, respectively), and falls occurring indoors (66/166, 39.8%) and outdoors (77/164, 48.0%) had similar rates of injury ($p=0.19$, chi-squared test). Further description of the specific locations of outdoor falls is shown in Supplemental Figure 1. Notably, 73 falls (44.5%) occurred within the vicinity of the home (driveway/street near home, yard/garden, porch/steps; Supplemental Figure 1). Similarly, among the set of outdoor injurious falls, 43.6% occurred in the vicinity of the home.

Most indoor falls occurred in the study participant's home (117 falls, 70.5%), with the location of other indoor falls shown in Supplemental Figure 1. Approximately one-third of falls in the home resulted in an injury (41/117). Falls occurring in the home were less likely to result in injury compared to falls occurring anywhere outside the home (OR = 0.51, $p=0.008$). Within the home, the stairs (24.8%), bedroom (18.8%), bathroom (14.5%), and living room (12.8%) were the most common areas for falls (Figure 1), with a similar breakdown of falls by room also observed for injurious falls (Figure 1). Among all 330 reported falls, falls most commonly occurred on cement/stone/brick (113 falls, 34.3%) and carpet (61 falls, 18.5%) (Figure 2 left); injurious falls most commonly occurred on cement/stone/brick (62 falls, 43.4%) and linoleum/tile/marble (29 falls, 20.3%; Figure 2 right).

Severity of VF damage was not associated with the likelihood of a fall occurring indoors as opposed to outdoors (OR 0.92, $p=0.55$), or the likelihood of a fall occurring in the home as opposed to anywhere outside the home (OR 1.17, $p=0.30$).

Circumstances surrounding falls

Patient narratives of their falls were used to create a word cloud regarding the circumstances around their fall (Figure 3). The most common words in patient fall narratives were "fell," "walking," "tripped," and "slipped" (Figure 3). The majority of patients were engaged in simple activities (standing, sitting, walking) prior to their fall, and this frequency was similar across patients with normal/near-normal VFs, moderate VF damage, and severe VF damage

(44 – 59% for all groups, $p=0.24$). A large majority of patients were wearing refractive correction prior to their fall, and this frequency was also similar across patients with normal/near-normal VFs, moderate VF damage, and severe VF damage (81 – 84%, $p=0.95$).

The most common contributing factors to falls cited by patients were tripping (44.8%), slipping (31.6%), uneven floor (23.8%;), and issues with vision (15.9%) (Figure 4 top). The most common contributing factors to injurious falls cited by patients were tripping (46.9%), slipping (32.0%), uneven floor (21.1%), and issues with vision (18.5%; Figure 4 bottom). Regression models incorporating GEE (to control for clustering by individual) were used to determine if any specific contributing factor (trip, slip, uneven ground, vision, wet surface, curb) was more likely to be reported by fallers with worse VF damage or other features (Table 3). Patients with lower (worse) IVF sensitivity were more likely to cite vision, but not any other factors, as contributing to their falls (OR = 2.11/5 dB decrement, $p=0.001$; $p>0.05$ for all other factors). Other features that increased the likelihood of patients citing specific contributing factors to falls included: younger age (for vision), less comorbid illness (trips and uneven flooring), male gender (slip), outdoor location (uneven ground and wet surface), and away-from-home location (uneven ground) (Table 3, $p<0.05$ for all).

Predictors of injurious falls

In univariate analyses, patients with normal/near-normal VFs, mild-moderate VF damage, and severe VF damage differed with regard to the number of falls resulting in a fracture ($p=0.03$), with patients with severe VF loss having the highest percentage sustaining a fracture (9.4%; Table 2). However, the likelihood that a fall would produce other specific injuries did not differ across severity category ($p>0.1$ for all; Table 2). The location of where medical visits occurred (in those sustaining a fall-related injury) also differed across groups ($p=0.02$), with persons with more advanced disease generally more likely to obtain care in walk-in clinics or the emergency room (Table 2). In univariate models, fall surface, number of medical comorbidities, and activity type before the fall were significantly associated with injury from a fall ($p<0.005$ for all). However, the particular room in which the fall occurred did not predict injury, fracture, or hospitalization after the fall ($p>0.46$ for all in GEE models).

Multivariate regression models incorporating GEE and including relevant covariates defined in univariate models were used to determine if IVF sensitivity or demographic features predicted a higher likelihood of injury, fracture, or hospitalization after a fall. VF damage (as measured by IVF sensitivity) did not predict whether a fall would be injurious ($p=0.60$), nor was it associated with fracture, or hospitalization after a fall. Similarly, multivariate analysis of inferior visual field sensitivity only did not predict whether a fall would be injurious and was not associated with an increased likelihood of injury, fracture, or hospitalization after a fall ($p>0.05$ for all). Falls on cement, as compared to falls on carpet (OR 2.64, $p=0.003$) and greater medical comorbidity (odds ratio 1.38/additional illness, $p=0.002$) were associated with a higher likelihood of sustaining an injury during a fall. African-American patients were more likely to be hospitalized after a fall (OR 5.69, $p=0.03$).

DISCUSSION

Here, we systematically documented the locations and circumstances of falls, and examined the role of disease severity in modulating the risk of fall-related injury in a cohort of glaucoma patients. Falls in our prospectively studied cohort of glaucoma patients were most likely to occur in or near the home, while the circumstances most frequently associated with falls were tripping, slipping, uneven flooring, and poor vision. Although persons with worse VF were more likely to cite poor vision as a contributing factor to a fall, the majority of circumstances and/or locations did not vary by severity of VF damage, suggesting that the scenarios producing falls may not change substantially across the spectrum of VF damage. Importantly, we also investigated the characteristics of injurious falls and found that glaucoma patients with greater VF damage were more likely to report a fracture after a fall and subsequently seek a higher level of medical care, though this association did not persist in multivariate analysis. Our findings can be utilized to develop fall-prevention approaches that best address the specific scenarios under which falls most often occur in this high-risk population.

The home was a common location for both indoor and outdoor falls, accounting for 71% of all falls, in accordance with previous studies showing rates between 67–77%.^{15,16,32,33} Within the home, we found that injurious falls most commonly occurred in the stairs and bedroom, which is also consistent with previous reports.^{16,32,34,35} As most adults spend the majority of their time indoors, many fall interventions have focused heavily on modifying the home environment to make it less hazardous, and our findings indicate that this method may also be effective in mitigating fall risk in glaucoma patients. However, an ideal intervention would also prevent outdoor falls given that a significant percentage of falls occurred outside the immediate home (including several which occurred just outside the home, i.e. the porch or yard) and that our multivariate analyses showed that these outside falls were more likely to cause injury. Though research into how to prevent outdoor falls is limited, there is some evidence to suggest that teaching older adults defensive techniques to recognize fall hazards and threats outside the home is effective.³⁶ As glaucoma patients have been shown to have increased difficulty with hazard perception,^{37,38} such approaches may be an effective adjunct to home modifications to prevent falls in this high-risk group, though more work will be needed to determine if glaucoma patients will still be able to utilize such an approach given their visual limitations.

Previous studies conducted in the general elderly population have shown that tripping, slipping, and environmental obstacles are the most common contributing factors for falls, which are consistent with our findings.^{16,39–41} It is widely believed that elderly adults experience more trips and slips because of age-related changes in posture and balance,^{42–44} and there is evidence indicating that patients with glaucoma are at even greater risk for these disturbances due to loss of visual input.^{45–47} While previous studies investigating fall circumstances did not find poor vision as a primary contributor to falls,^{16,38–40} in our study, poor vision was the fourth most common fall circumstance. This suggests that glaucoma patients may indeed be more likely to experience falls from vision-related issues than the general elderly population. It is quite possible that vision also played a role in contributing to tripping and slipping in this population but the extent to which it contributed is unclear. In

general, however, our findings suggest that older adults with VF loss may be engaging in the same kinds of activities and encounter the same types of situations that lead to falls as their non-visually impaired counterparts, suggesting that fall-prevention interventions developed for the general adult population may be a good starting point when developing interventions designed for patients with glaucoma.

Furthermore, in this study, glaucoma severity was not associated with the location or circumstances of falls. One possible theory for this finding is that glaucoma patients with greater VF loss learn to adjust to the types of falls that would be expected to be more common among patients with greater VF damage such as tripping over unseen environmental obstacles (for instance, glaucoma patients often focus their gaze on the ground while walking), and as a result these patients fall for the same reasons as those with milder VF loss. Another possibility is that VF loss may act as a modifier of fall risk in general and increases the risk of many types of falls similar to how issues with balance increases the risk of falling in many situations. This would then lead to an increased fall risk without increasing the risk of any specific types of falls. However, a limitation in interpreting this finding is the relatively small sample size of patients with severe VF loss (n=14).

Multivariate analysis demonstrated that fall surface (cement, tile, etc) and number of medical comorbidities were associated with injury after a fall but overall, our post-fall survey was not able to identify many circumstances or locations that distinguish injurious falls from non-injurious falls, suggesting that both types of falls may result from similar conditions/activities. An important implication of this result is falls, even when not accompanied by an injury, should not be considered benign, as the same conditions/activities which produced the fall may well lead to an injurious fall the next time around. In other words, a person who experiences a non-injurious fall when performing a certain task (eg walking to the bathroom) may be just as likely to experience an injurious fall the next time they engage in the same activity. Alternately, it is possible that the ability to avoid injuries as a result of a fall result from covariates that were not measured in the current study. Our findings suggest that the risk of injury from a fall may be more strongly related to the characteristics of the patient (age, osteoporosis) or to other specifics of the fall process (direction, how they braced for the fall, etc) that were not captured by our post-fall questionnaire.

Our univariate analyses showed that glaucoma patients with greater VF damage were more likely to experience a fracture after a fall and seek more costly forms of medical care (urgent care center or emergency room), findings which are consistent with previous reports.⁴⁸⁻⁵³ However, neither of these associations persisted in multivariate analysis. Thus, the association of greater VF damage with fractures and more costly care may be the result of confounders such as age or comorbid disease. Nonetheless, our univariate findings are relevant clinically, as it points to worse VF damage serving as a marker for significant injurious and costly care, suggesting that persons with greater degrees of VF damage should be prioritized for fall-prevention efforts.

Our study has several limitations. First, falls are not very common in any given year, so even with over 200 patients followed for over a two year period, the number of falls was limited.

There is also a potential for recall bias as fall circumstances data was collected retrospectively at the end of a calendar month, and patients may not have remembered the circumstances of their fall accurately enough to allow detection of relevant factors, though monthly calendars remain as the best current approach. Additionally, there appeared to be selection bias, with individuals more likely to have fallen in the past, or using a mobility aid, to participate. Thus, our results may not reflect the falls of those who have less severe mobility issues. Lastly, while no surfaces increased the risk of falls, the percentage of steps taken on different surfaces is unknown, and it is possible that some surfaces increase the risk of any individual step leading to a fall.

In summary, our study demonstrated that glaucoma patients are most likely to fall in or near their homes and that the most common fall circumstances are trips, slips, and uneven floors. Furthermore, our findings suggest that the circumstances and locations of falls do not vary based on the degree of VF damage and that the fall circumstances and locations in elderly patients with glaucoma are similar to what has been observed in the general elderly population. As a take home point for the practicing ophthalmologist, it may be beneficial to discuss the most common location of falls, particularly falls occurring within the home, and advise the use of publicly available home safety guidelines for glaucoma patients who are known to have fallen or are at increased risk of falling. Future research, perhaps using wearable sensors, should further explore how the immediate circumstances of a fall vary with VF damage.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Floor plan showing the location distribution of falls and injurious falls occurring within the home. Percentages are based on 117 total falls and 41 injurious falls.

Figure 2.
left Distribution of surfaces on which falls occurred. Figure 2 right Distribution of surfaces on which injurious falls occurred.

Figure 3.

Words used by patients to characterize the circumstances and events that led to their falls. Larger print sizes represent words more frequently used within the narratives provided by patients to describe their falls.

Figure 4.

top Percentage of falls amongst patients with different degrees of VF damage which were reported to have occurred as a result of specific contributing factors. Figure 4 bottom Percentage of injurious falls amongst patients with different degrees of VF damage which were reported to have occurred as a result of specific contributing factors. Normal/near-normal VF damage was defined as an average IVF sensitivity greater than 28 dB, mild-moderate VF damage was defined as an average IVF sensitivity between 23 and 28 dB, and severe VF damage was defined as an IVF sensitivity below 23 dB.

Table 1

Characteristics of the study population stratified by severity of visual field damage.

Variable	All participants (n = 142)	Normal/near-normal VF ^I (n = 70)	Mild-moderate VF damage ^I (n = 58)	Severe VF damage ^I (n = 14)	P-value [*]
Sociodemographic					
Age, years, mean (SD)	71.3 (7.2)	69.6 (6.0)	73.3 (8.3)	71.6 (6.7)	0.02
Male sex, n (%)	64 (45.1%)	34 (48.6%)	26 (44.8%)	4 (28.6%)	0.39
Race, n (%)	–	–	–	–	<0.001
White	101 (71.1%)	52 (74.3%)	46 (79.3%)	3 (21.4%)	–
African-American	33 (23.2%)	14 (20.0%)	10 (17.2%)	9 (64.3%)	–
Asian/Pacific-Islander	3 (2.1%)	1 (1.4%)	2 (3.5%)	0 (0%)	–
Other	5 (3.5%)	3 (4.3%)	0 (0%)	2 (14.3%)	–
Highest level of education completed, n (%)	–	–	–	–	0.62
Less than college	39 (27.5%)	17 (24.3%)	18 (31.0%)	4 (28.6%)	–
4-year college	31 (21.8%)	18 (25.7%)	9 (15.5%)	4 (28.6%)	–
Master's or Doctorate program	72 (50.7%)	35 (50.0%)	31 (53.5%)	6 (42.9%)	–
Lives alone, n (%)	30 (21.1%)	11 (15.7%)	15 (25.9%)	4 (28.6%)	0.29
Married, n (%)	90 (63.4%)	49 (70.0%)	34 (58.6%)	7 (50.0%)	0.23
Has pets in home, n (%)	52 (36.6%)	26 (37.1%)	21 (36.2%)	5 (35.7%)	0.99
Employed, n (%)	46 (32.4%)	22 (31.4%)	21 (36.2%)	3 (21.4%)	0.55
Health					
Number of prescription medications, mean (SD) ²	4.7 (3.3)	4.4 (3.1)	4.7 (3.1)	6.5 (4.3)	0.08
Number of medical comorbidities, mean (SD) ³	2.5 (1.7)	2.6 (1.7)	2.4 (1.7)	2.6 (1.8)	0.63
MMSE-blind score, mean (SD) ⁴	20.2 (1.5)	20.2 (1.4)	20.2 (1.4)	19.9 (2.3)	0.84
Depressive symptoms, n (%)	6 (4.2%)	3 (4.3%)	2 (3.4%)	1 (7.1%)	0.83
Home environment⁵					
Footwear in home	–	–	–	–	0.61
Barefoot	5 (5.1%)	2 (4.1%)	3 (7.5%)	0 (0%)	–
Socks	8 (8.1%)	5 (10.2%)	3 (7.5%)	0 (0%)	–

Variable	All participants (n = 142)	Normal/near-normal VF ¹ (n = 70)	Mild-moderate VF damage ¹ (n = 58)	Severe VF damage ¹ (n = 14)	P-value *
Slippers	23 (23.2%)	10 (20.4%)	8 (20.0%)	5 (50.0%)	–
Sneakers	43 (43.4%)	23 (46.9%)	17 (42.5%)	3 (30.0%)	–
Other	20 (20.2%)	9 (18.4%)	9 (22.5%)	2 (20.0%)	–
Use of assistive device at home ⁶	7 (7.0%)	2 (4.0%)	4 (10.0%)	1 (10.0%)	0.50
Vision					
IVF sensitivity ⁷ , dB, mean (SD)	27.1 (4.0)	29.7 (1.1)	26.3 (1.3)	17.6 (5.0)	<0.001
LogMAR visual acuity, better eye, mean (SD)**	0.09 (0.21)	0.06 (0.23)	0.09 (0.10)	0.27 (0.34)	0.002

MMSE-blind = Mini-Mental State Examination for the visually impaired; IVF = integrated visual field; LogMAR = logarithm of the minimum angle of resolution; logCS = logarithm contrast sensitivity

¹Normal/near-normal VF damage was defined as an average IVF sensitivity greater than 28 dB, mild-moderate VF damage was defined as an average IVF sensitivity between 23 and 28 dB, and severe VF damage was defined as an IVF sensitivity below 23 dB.

²Excludes over-the-counter medications.

³Maximum of 15.

⁴Maximum score of 22.

⁵N = 100, taken from home assessment data.

⁶Includes cane, walking stick, and wheelchair.

⁷Average sensitivity of points from the integrated visual field

* p-values represent differences across groups defined by disease severity.

Table 2

Falls data and consequences of falls stratified by severity of visual field damage.

Variable	All falls (n = 330)	Normal/near-normal VF ¹ (n = 144)	Mild-moderate VF loss ¹ (n = 154)	Severe VF loss ¹ (n = 32)	P-value
Study period and falls data					
Duration of follow-up, months, mean (SD)	24.5 (4.6)	24.8 (4.8)	24.0 (4.6)	25.7 (3.5)	0.35
Number of falls per patient over study period, mean (SD)	2.3 (1.9)	2.1 (1.8)	2.7 (2.0)	2.3 (1.7)	0.20
Consequences of falls					
Any injury	143 (43.3%)	67 (46.5%)	61 (39.6%)	15 (46.9%)	0.44
Mild injury ²	97 (29.4%)	49 (34.0%)	40 (26.0%)	8 (25.0%)	0.14
Moderate injury ³	24 (7.3%)	13 (9.0%)	8 (5.2%)	3 (9.4%)	0.14
Severe injury ⁴	22 (6.7%)	5 (3.5%)	13 (8.4%)	4 (12.5%)	0.14
Broken bone/fracture	15 (4.5%)	2 (1.4%)	10 (6.5%)	3 (9.4%)	0.03
Hospital admission	11 (3.3%)	3 (2.1%)	4 (2.6%)	4 (12.5%)	0.15
Visited medical professional	49 (14.8%)	16 (11.1%)	25 (16.2%)	8 (25.0%)	<0.05
Location of medical visit	–	–	–	–	<0.05
Medical office	19 (5.8%)	11 (7.6%)	7 (4.5%)	1 (3.1%)	–
Urgent walk-in clinic	9 (2.7%)	1 (0.7%)	7 (4.5%)	1 (3.1%)	–
Emergency room	20 (6.1%)	4 (2.8%)	10 (6.5%)	6 (18.8%)	–

¹Normal/near-normal VF damage was defined as an average IVF sensitivity greater than 28 dB, mild-moderate VF damage was defined as an average IVF sensitivity between 23 and 28 dB, and severe VF damage was defined as an IVF sensitivity below 23 dB.

²Mild injury was defined as experiencing at least one of the following: pain, bruising, or swelling.

³Moderate injury was defined as experiencing at least one of the following: sprained ligament/tendon, joint dislocation, or pulled muscle.

⁴Severe injury was defined as experiencing at least one of the following: broken bone/fracture or hospital admission.

Table 3

Patient and location features associated with a specific factor being reported as contributing to a fall.

Patient Features	Contributing Factors/ ¹ Odds Ratio						
	Interval	Trips	Slips	Uneven Ground	Vision	Wet Surface	Curb
Age	5 years older	0.92 *	0.91 *	0.92 *	0.74 **	0.88 *	0.98 *
African-American	vs. all other races	1.31 *	0.73 *	1.39 *	0.55 *	0.36 *	1.75 *
Male	vs. Female	1.01 *	1.81 **	1.01 *	1.14 *	0.93 *	2.14 *
Medical Comorbidities	1 additional comorbidity	0.80 **	1.17 *	0.76 **	1.17 *	0.99 *	0.96 *
IVF Sensitivity ²	5 db worse	0.98 *	0.82 *	1.00 *	2.1 **	1.01 *	1.52 *
Fall Location ³							
Home	vs. falls occurring anywhere outside the home	0.77 *	0.70 *	0.28 **	0.85 *	0.31 *	–
Outdoors	vs. indoor falls	1.57 *	1.09 *	5.52 **	1.24 *	2.1 **	–

* p>0.05

** p<0.05

¹ Results were derived from a model in which each fall was an observation. The contributing factor was considered as the outcome (positive if the factor contributed to a fall, negative if it did not contribute to a fall). Each of the patient and location features were considered as exposure variables.

² Normal/near-normal VF damage was defined as an average IVF sensitivity greater than 28 dB, mild-moderate VF damage was defined as an average IVF sensitivity between 23 and 28 dB, and severe VF damage was defined as an IVF sensitivity below 23 dB.

³ Curbs were not considered in the analysis of home and outdoors, as curbs only exist outdoors.