Published in final edited form as:

Ophthalmology. 2017 April ; 124(4): 562–571. doi:10.1016/j.ophtha.2016.11.032.

Quantifying fall-related hazards in the homes of persons with glaucoma

Andrea V. Yonge, BS¹, Bonnielin K. Swenor, PhD, MPH¹, Rhonda Miller, BA¹, Victoria Goldhammer, MS, OTR/L², Sheila K. West, PhD, PharmD¹, David S. Friedman, MD, PhD¹, Laura N. Gitlin, PhD², and Pradeep Y. Ramulu, MD, PhD¹

¹Wilmer Eye Institute, Johns Hopkins University, Baltimore, MD

²Center for Innovative Care in Aging, School of Nursing, Johns Hopkins University, Baltimore, MD

Abstract

Objective—To characterize fall-related hazards in the homes of persons with suspected or diagnosed glaucoma, and to determine whether those with worse visual field (VF) damage have fewer home hazards.

Design—Cross-sectional study using baseline (2013–2015) data from the ongoing Falls in Glaucoma Study (FIGS).

Participants—One-hundred seventy-four (71.0%) of 245 FIGS participants agreeing to the home assessment.

Methods—Participants' homes were assessed using the Home Environment Assessment for the Visually Impaired (HEAVI). A single evaluator assessed up to 127 potential hazards in eight home regions. In the clinic, binocular contrast sensitivity (CS) and better-eye visual acuity (VA) were evaluated, and 24-2 VFs were obtained to calculate average integrated VF (IVF) sensitivity.

Main outcome measure—Total number of home hazards.

Results—No significant visual or demographic differences were noted between participants who did and did not complete the home assessment ($p>0.09$ for all measures). Mean age among those completing the home assessment ($n=174$) was 71.1 years, and IVF sensitivity ranged from 5.6 to 33.4 dB (mean=27.2 dB, SD=4.0 dB). The mean number of items graded per home was 85.2 (SD=13.2), and an average of 32.7 (38.3%) were identified as hazards. IVF sensitivity, CS, and VA were not associated with total home hazards or the number of hazards in any given room ($p>0.06$ for all visual measures and rooms). The bathroom contained the greatest number of hazards (mean=7.9; 54.2% of graded items classified as hazardous), and the most common hazards

Corresponding author: Pradeep Y. Ramulu MD MHS PhD, Johns Hopkins Hospital, 600 North Wolfe Street, Maumenee B110, Baltimore, MD 21287, pramulu@jhmi.edu.

Conflict of Interest: No conflicting relationship exists for any author.

This article contains additional online-only material. The following should appear online-only: Tables 3, 4, 5, 6, and 7.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

identified in at least one room were ambient lighting <300 lux and exposed light bulbs. Only 27.9% of graded rooms had adequate lighting. IVF sensitivity, CS, and VA were not associated with home lighting levels ($p>0.18$ for all), but brighter room lighting was noted in the homes of participants with higher median income ($p<0.001$).

Conclusions—Multiple home fall hazards were identified in the study population, and hazard numbers were not lower for persons with worse VF damage, suggesting that individuals with more advanced glaucoma do not adapt their homes for safety. Further work should investigate whether addressing home hazards is an effective intervention for preventing falls in this high-risk group.

Introduction

Falls are a leading cause of injury and death among older adults,¹ and occur in one third of adults over the age of 65 annually.^{2,3} Ten to twenty percent of falls cause serious injuries such as fractures or head trauma,⁴ and up to 40% of those who fall will restrict their activities of daily living, leading to a decline in physical activity and social interactions.⁵ Falls can occur as a confluence of intrinsic factors (e.g. age, sex, prior fall history, medical comorbidities, medications, muscle weakness, sensory changes) and extrinsic factors (e.g. the home environment),⁶ with extrinsic risk factors serving as ideal targets of interventions given that they are more easily modifiable, sometimes at low cost. The home environment represents a particularly important factor given that the majority of falls occur in or near the home,^{7–9} and because home modifications can effectively reduce fall rates.¹⁰

Glaucoma is associated with an increased risk of falls^{11–13} due to visual field (VF) loss and poor contrast sensitivity (CS).^{14–18} As the population ages, glaucoma-related falls and disability will become an increasing burden on society.^{19,20} The home environment is particularly relevant to falls in glaucoma patients, who report significant fear of falling,²¹ are increasingly home-bound at greater levels of VF damage,²² and are more likely to encounter difficulty with environmental hazards due to impaired hazard perception.

Hazards identified through home assessments have been associated with increased fall risk, though prior assessments have not been tailored to individuals with visual limitations.^{23–27} Importantly, most home assessments do not adequately measure lighting conditions (wattage, placement, window coverings), color contrast, visual distractions, or glare.²⁸ Awareness of home lighting hazards is crucial for patients with visual impairment,^{29,30} as poor lighting and environmental contrast are associated with more falls and difficulty with mobility.^{31,32} No studies have characterized home fall hazards among patients with glaucoma, nor have they explored if homes are less hazardous at greater levels of VF loss, which would suggest environmental adaptation as visual impairment progresses and fall risk increases.

Here, we use a validated home assessment tool to identify fall-related hazards in the homes of individuals with suspected or diagnosed glaucoma. To explore the hypothesis that individuals with more advanced glaucoma adapt their environment, we examine the relationship between the number of home hazards and the adequacy of home lighting across patients with varying degrees of VF loss. We also identify the most common home falls

hazards in glaucoma patients, which will help guide the creation of targeted interventions to prevent falls in this at-risk population.

Methods

Participants

Study participants were recruited from patients presenting to the Johns Hopkins Wilmer Eye Institute glaucoma clinic. Eligible patients: (1) were 60 years of age (or due to turn 60 during the study period), (2) had a chart diagnosis of primary open angle glaucoma, primary angle closure glaucoma, pseudoexfoliation glaucoma, pigmentary glaucoma, or glaucoma suspect, and (3) were able to perform VF testing. Patients 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, were hospitalized in the last month, or lived >60 miles from Baltimore. Additionally, data were collected for one week on all glaucoma clinic patients likely to have met study inclusion criteria to determine representativeness of the recruited sample. The Falls in Glaucoma Study (FIGS) protocol was approved by the Johns Hopkins Institutional Review Boards, and all subjects signed written informed consent authorizing all study procedures.

Procedures

All FIGS participants underwent a comprehensive baseline examination to assess visual function, including visual acuity (VA), Humphrey 24-2 VFs performed on a HFA-2 machine (Carl Zeiss Meditec, Dublin, CA), and contrast sensitivity as measured by the Mars Letter Contrast Sensitivity Test (Mars Perceptrix Corporation, Chappaqua, NY). Better-eye VA and binocular MARS CS were analyzed as the logarithm of the minimum angle of resolution (logMAR)³³ and logarithm contrast sensitivity (logCS) units, respectively. Average sensitivity (in dB) across visual field points 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.^{34,35} Points from the right and left eye VFs were integrated using the maximum sensitivity between the two eyes. Exponentiated sensitivity points 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. To determine cut points for classifying glaucoma severity using IVF sensitivity, a regression analysis was first performed for IVF total sensitivity and better-eye MD for all patients with visual field data (n=241) to calculate approximate IVF sensitivities for various 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.³⁶ Normal mean IVF sensitivity in older patients is roughly 31 dB.

All FIGS participants were asked about sociodemographic characteristics and living arrangements, including home type, home ownership, and housing occupancy. Participants also provided information on 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).³⁷ Depressive symptoms were assessed using the Geriatric Depression Scale, with scores of greater than 6/15 classified as positive for depression.³⁸ Cognitive status was evaluated using the Mini-Mental State Examination for the visually impaired (MMSE-blind).³⁹ Median income was estimated from American Community Survey data provided by the United States Census Bureau.⁴⁰

Participants underwent a home visit to characterize fall hazards unless they declined or were unable to coordinate a visit. Study participants were instructed not to tidy any rooms prior to evaluation of the home. For lighting measurements, participants were asked to set the lighting and window coverings of each room to reflect typical conditions when in use. Home visits were conducted year-round by a single trained evaluator (RM) and were restricted to daytime hours.

Measures

The Home Environment Assessment for the Visually Impaired (HEAVI) evaluates 46 distinct items, each in up to eight areas of the home (total of 127 hazards): 1) entryway, 2) living room, 3) dining room, 4) kitchen, 5) bedroom, 6) bathroom, 7) stairs, and 8) hallway. The HEAVI is designed to be completed in one hour and does not require prior training in home evaluation or modification. The living room and dining room were not evaluated if infrequently used (<1 hour daily); all other rooms were evaluated unless not present or declined by the participant. A prior validation sample demonstrated a strong correlation between the number of hazards identified by the grader used in this study and an occupational therapist with expertise in modifying homes (VG; Swenor BK, Yonge AV, Goldhammer V, et al. Evaluation of a home assessment tool designed to quantify home-related hazards in the visually impaired. In submission.).

Table 1 summarizes the items evaluated and lists the potential rooms where each item might be assessed. Items graded as "Yes" were classified as a hazard; items graded as "No" or "Not assessed" were not. Light intensity indoors and outdoors was measured in lux using a digital light meter (Dr. Meter model LX1330B; Hishgadget Inc., Union City, CA). Friction was measured using a digital slip meter (American Slip Meter model 825; American Slip Meter Inc., Englewood, FL). Size and distance measurements were rounded to the nearest half-inch (e.g. height of stair risers, width of doorway).

Statistical analyses

Differences between participants who did or did not complete the home assessment were evaluated using chi-squared analyses for categorical values and Mann Whitney-U tests for continuous variables. Continuous measures within the home assessment were dichotomized for analysis based on publically available guidelines.^{41–44} Hazards were first calculated as the number and percentage (among graded items) of hazards for each room and the full home. We then identified the most common hazards by calculating the number and percentage of rooms demonstrating each individual hazard, as well as the percentage of homes containing that hazard in at least one room.

Multiple linear regression models were used to test the hypothesis that glaucoma patients with lower IVF sensitivity (more severe disease) would exhibit fewer hazards in individual

rooms and across the whole home. Age, sex, and race were included as fixed covariates, as were any variables associated with home hazards in univariate analysis. One-way ANOVA tests were used to compare differences in room and home hazards across the three categories of VF loss. Models were tested to confirm normality of residuals.

Additional models incorporating general estimating equations (GEE) were utilized to evaluate whether IVF sensitivity was related to differences in room lighting, and also to identify rooms with the worst lighting. Lighting values were log transformed to produce normally distributed residuals, and regression coefficients predicting $\log(\text{lighting})$ were exponentiated in order to define the percent increase or decrease in lighting associated with each variable. One-way ANOVA tests were used to compare differences in $\log(\text{lighting})$ across the three categories of VF loss. Finally, GEE models were used to identify if item class (lighting, flooring, handrails, furniture, other) or specific rooms influenced the likelihood of an item being graded as hazardous. All data were analyzed using Stata 14.0 (StataCorp LP, College Station, TX).

Results

Characteristics of patient sample

One-hundred seventy-four of 245 (71.0%) recruited patients completed the home assessment. No significant differences were observed between patients who did or did not participate in the home assessment (Table 2, $p>0.09$ for all variables). Additionally, the 174 patients who completed the home assessment were representative of eligible glaucoma clinic patients ($n=258$ surveyed patients), with no significant differences noted in age, sex, race, education, and medical comorbidities ($p>0.06$ for all). Mean age was 71.1 years ($SD=7.6$) among the 174 patients who underwent the home visit ("participants"). Participants were primarily Caucasian and male, and average IVF sensitivity was 27.2 dB ($SD=4.0$; range=5.6–33.4, interquartile range 25.9–29.7), logMAR VA was 0.11 ($SD=0.3$), and logCS was 1.7 ($SD=0.2$). Among the 174 participants, 88 participants (50.6%) had normal or near-normal VF loss (mean IVF sensitivity 29.8, $SD=1.2$), 69 (39.7%) had mild-moderate VF loss (mean IVF sensitivity 26.2, $SD=1.3$), and 17 (9.8%) had severe VF loss (mean IVF sensitivity 17.7, $SD=4.5$). One-hundred thirty-five of the 172 participants had a diagnosis of glaucoma; thirty-nine participants were glaucoma suspects. The mean participant score on the MMSE-blind was 20.2 (range 14–22; maximum score 22).

Home Hazards

The 174 dwellings assessed included 141 (81.0%) houses and 33 (19.0%) apartments; Table 3 lists the total number of each room evaluated. An average of 7 ($SD=0.8$) rooms and 85.2 ($SD=13.2$) items were assessed in each home, and the mean number of items identified as hazards was 32.7 (38.3%). The greatest number of observed hazards was found in the bathroom (mean=7.9; $SD=2.0$; 54.1% of graded items identified as hazardous), stairs (mean=6.5; $SD=1.7$; 40.7% of graded items), and entryway (mean=4.8; $SD=2.7$; 28.4% of graded items). Rooms demonstrating a high percentage of total room items graded as hazardous included the bathroom, dining room, and stairs, with 54.1%, 42.6%, and 40.7% of

graded items identified as hazardous in each room, respectively (Figure 1; Table 3, available at <http://www.aaojournal.org>).

The most common hazards identified in one or more rooms of the home were ambient lighting <300 lux (98.9% of homes), exposed light bulbs (96.0%), lack of grab bars by the toilet (90.8%), door threshold height >0.5 inches (84.5%), and seats without arm rests (83.9%; Table 4, available at <http://www.aaojournal.org>).

Given that some items (e.g. lighting) may be hazardous in some rooms but not in others, we identified items that were frequently hazardous within specific rooms disproportionate to the overall likelihood of the item being hazardous across all home locations (Table 5, available at <http://www.aaojournal.org>). Examples of disproportionately identified hazards included seats without arm rests in the dining room (88.1% vs. average of 40.1% across four total rooms), light switches only accessible from fully inside room in the living room (46.5% vs. average of 16.6% across six total rooms), and floor >50% cluttered in the bedroom (15.0% vs. average of 5.2% across six total rooms).

Relationship to Visual Measures

Patients with suspected and diagnosed glaucoma showed no difference in total number of home hazards or number of hazards in any given room except for the bathroom, in which patients with diagnosed glaucoma showed more hazards ($p=0.009$; $p>0.08$ for all other rooms and whole home). In simple linear regression models, MMSE-blind scores, depression, number of medical comorbidities, and median income were not significantly associated with total home hazards ($p>0.09$ for all variables); living alone was significantly associated and was included in multiple regression models ($p=0.002$). IVF sensitivity evaluated as a continuous measure was not associated with the total number of home hazards ($p=0.15$) or number of hazards in any given room ($p>0.10$ for all). Across the three specified levels of VF loss, there was no difference in total home hazards or hazards within any specific room other than the dining room ($p=0.02$), in which those with moderate VF loss showed the most hazards ($p>0.13$ for all other rooms and whole home; Figure 2). Similarly, neither CS nor VA was associated with the total number of home hazards ($p=0.80$ and $p=0.93$, respectively) or number of hazards in any given room ($p>0.07$ and $p>0.06$ for all, respectively). Living alone was significantly associated with fewer total home hazards in all three multiple regression models for vision (4.4 fewer hazards if living alone, $p<0.004$ in all three models).

In univariate GEE regression models, MMSE-blind scores, depression, number of medical comorbidities, and living alone were not significantly associated with log home lighting ($p>0.22$ for all variables); median income was significantly associated and was included in full models ($p<0.001$). In multivariate GEE models, lighting was not associated with IVF sensitivity, contrast sensitivity, or visual acuity ($p>0.18$ for all visual measures; Table 6, available at <http://www.aaojournal.org>). There was no difference in log(lightning) across the three levels of VF loss in all rooms ($p>0.05$; Figure 3). Brighter room lighting was noted in the homes of participants with higher median income (5.7% change in lighting per \$10,000 increase; 95% confidence interval 2.6 to 8.9%; $p<0.001$), but lighting was not associated with any other demographic features (age, sex, race; $p>0.11$ for all; Table 6, available at

<http://www.aaojournal.org>). Significantly dimmer lighting was observed in several rooms (stairs, hallway, bedroom entryway, living room; $p < 0.001$ for all) as compared to the bathroom (reference group; Figure 1; Table 6, available at <http://www.aaojournal.org>). Average lighting in the bathroom, dining room, and kitchen met the minimum requirement of 300 lux; average lighting levels in all other rooms did not meet recommended levels. Overall, only 27.9% of graded rooms demonstrated adequate lighting.

Influence of Areas/Items on Hazard Likelihood

Additional logistic regression models incorporating GEE were used to determine if specific rooms or item categories (handrails, floors, lighting, furniture, other) influenced the likelihood of items being graded as hazardous (Table 7, available at <http://www.aaojournal.org>). Graded items were more likely to be identified as hazardous in all rooms as compared to the entryway (reference group; $p < 0.004$ for all), with the highest likelihood in the bathroom and dining room (odds ratio 2.75 and 1.82, respectively). Items related to handrails and lighting were more likely to be hazardous as compared to flooring items (reference group; $p < 0.001$; Table 7, available at <http://www.aaojournal.org>).

Discussion

Older adults with glaucoma have hazardous homes that may increase their risk of falls, suggesting that the home environment is an important modifiable risk factor to consider in this patient population. Importantly, individuals with more severe VF damage had the same high number of home hazards as those with lesser levels of VF damage, and home lighting was similarly poor, suggesting that those most in need of a safer home environment are not making adaptations that could potentially reduce their likelihood of falling. These findings suggest that those with more severe glaucoma are unaware of their predisposition to falls, unaware of how their needs (i.e. the need to minimize fall hazards in the home) change as they develop VF damage, or unable/unmotivated to address these hazards. Indeed, previous research has shown that patients with bilateral VF loss due to glaucoma may report few or no symptoms, highlighting the disconnect between clinical test results and perceived visual disability.⁴⁵

Our findings are consistent with prior research among older adults with non-visual disabilities, which showed similar home hazard frequencies and numbers in persons with or without disability.⁴⁶ It is unclear, however, why hazards are unaddressed by health systems and older adults. One group found that 97% of an older Australian population rated their homes as fairly or very safe even though 80% of homes had identifiable hazards.⁴⁷ Additionally, 88% of participants identified falls as the most common type of accident in older people, and 87% could name at least one measure to make their home safer. These data suggest that while older individuals understand the significance of falls and are aware of adaptations that might protect against falls, they fail to implement these changes within their own homes. Prior work has found that adults with dementia demonstrate fewer home hazards when living with a caregiver, suggesting that adaptations can be made in impaired populations but may require outside influence (family or health care providers) to initiate these changes.²³ Interestingly, we found that living alone was associated with fewer home

hazards. Individuals living with visually impaired persons may in fact contribute to clutter and other hazards, particularly if family members are older and/or disabled. There is a clear need for physicians and therapists to provide information and guidance to both patients and families so that they may improve the safety of their homes.

Our work highlights specific rooms that harbor fall hazards and specific items likely to be hazardous in individuals with suspected or diagnosed glaucoma, both of which should help target home modification interventions. The bathroom was the most hazardous room, with a mean of 7.9 bathroom hazards per home (54.1% of graded bathroom items identified as hazardous). These findings are consistent with prior studies in older adults, which have demonstrated significant fall hazards in 50–70% of bathrooms, more than any other room of the home.^{23,46–49} Other rooms demonstrating a high percentage of hazards included the dining room and stairs. The most prevalent hazards were ambient lighting <300 lux, exposed light bulbs, lack of grab bars by the toilet, and door threshold >0.5 inches, some of which have also been identified as common hazards in prior work.^{23,48,50} We also found that items could vary in the frequency they were graded as hazardous across rooms, suggesting that item type and location may interact with regard to the probability of an item being hazardous.

It is unclear whether more hazards in a room translates into more falls in that area of the home, and the most common hazards may not represent the most important ones that should be prioritized in fall prevention efforts. Leclerc et al⁴⁹ identified the bathroom as the most hazardous room, yet falls most commonly occurred in the bedroom and kitchen in their population of community-dwelling older adults. Several studies have shown correlations between specific or overall hazards and in-home falls, though these studies did not consider the specific room in which the patient fell or explain how hazards may play a causative role in these falls.^{50–52} Participants in the present study are currently maintaining falls calendars and providing details about the location and circumstances of their falls, so it will be possible to examine if observed hazards are associated with increased falls in those rooms.

Lighting was generally inadequate in most homes, with the average ambient lighting levels in only the dining room, kitchen, and bathroom meeting the minimum requirement of 300 lux. Average room lighting did not change with increasing severity of VF damage, though better room lighting was associated with higher median income. Dong et al⁵³ similarly found a higher prevalence of self-neglect and home environmental hazards (such as lighting problems) in community-dwelling older adults with lower income levels, suggesting that individuals of lower socioeconomic status may lack the knowledge or resources necessary to maintain sufficient lighting in their homes. Prior studies objectively measuring ambient home lighting in homes of the visually impaired found that average home lighting intensity was below recommended levels in the vast majority (>85%) of homes.^{29,54} Similarly, Bakker et al⁵⁵ found that only 15% of community dwelling homebound older adults had adequate ambient light levels, though 97% of participants rated their lighting as adequate; in addition, no significant difference in ambient light was noted in homes of those with and without low vision. Dim lighting in the home has been directly associated with falls, as navigational skills, hazard perception, and postural stability are impaired in this setting.^{31,32} Furthermore, better home lighting has been associated with improved VA and CS in older

adults with vision impairment, suggesting that decreased lighting may be particularly problematic in those with poor vision.^{29,56}

Several study limitations are worth mentioning. Not all patients participated in the home evaluation, which could have led to participation bias. Some patients who did agree to the home assessment declined evaluation of specific rooms; if these rooms were particularly messy, these houses would incorrectly appear less hazardous. Patients may have cleaned or staged their home for the evaluation, precluding detection of hazards that are typically present in that home. We did not evaluate the living room or dining room if the patient spent less than one hour per day in the room; however, people are still at risk of falling if exposed to hazards in areas of the home that are not commonly used. Finally, the HEAVI evaluates some items immediately outside the home, for example the sidewalk and front pathway, but it does not fully describe outdoor hazards that may be present in the driveway or yard.

In summary, hazard frequency did not vary by severity of visual field impairment, suggesting that individuals with more advanced glaucoma do not adapt their homes for safety. Additionally, large numbers of hazards were found, suggesting that patients' homes should be considered a potential source of fall risk. Given the number and type of hazards detected in this study, as well as prior evidence suggesting that hazard modification can reduce falls in older populations,¹⁰ performing a home assessment and educating patients about simple, low-cost home modifications (e.g. better lighting) should be evaluated as a treatment for ophthalmic patients at high risk for falls, including older persons, patients with significant VF damage, and any person who has recently experienced a fall.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial Support: This research was supported in part by NIH grant EY022976 and the Research to Prevent Blindness Robert and Helen Schaub Special Scholar Award. All funding organizations had no role in the design or conduct of this research.

This research was supported in part by NIH grant EY022976 and the Research to Prevent Blindness Robert and Helen Schaub Special Scholar Award. All funding organizations had no role in the design or conduct of this research. Figure illustration assistance was provided by Jerry Lai, M.Arch. The corresponding author had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Abbreviations

VF	visual field
FIGS	Falls in Glaucoma Study
HEAVI	Home Environment Assessment for the Visually Impaired
CS	contrast sensitivity
VA	visual acuity

IVF	integrated visual field
MD	mean deviation
MMSE-blind	Mini-Mental State Examination for the visually impaired
GEE	generalized estimating equations

References

- Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. [Accessed August 24, 2015] Web-based Injury Statistics Query and Reporting System (WISQARS). Available at: <http://www.cdc.gov/injury/wisqars>
- Hausdorff JM, Rios DA, Edelberg HK. Gait variability and fall risk in community-living older adults: a 1-year prospective study. *Arch Phys Med Rehabil.* 2001; 82:1050–6. [PubMed: 11494184]
- Peel NM, Kassulke DJ, McClure RJ. Population based study of hospitalised fall related injuries in older people. *Inj Prev.* 2002; 8:280–3. [PubMed: 12460962]
- Alexander BH, Rivara FP, Wolf ME. The cost and frequency of hospitalization for fall-related injuries in older adults. *Am J Public Health.* 1992; 82:1020–3. [PubMed: 1609903]
- Zijlstra GA, van Haastregt JC, van Eijk JT, et al. Prevalence and correlates of fear of falling, and associated avoidance of activity in the general population of community-living older people. *Age Ageing.* 2007; 36:304–9. [PubMed: 17379605]
- Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society. Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. *J Am Geriatr Soc.* 2011; 59:148–57. [PubMed: 21226685]
- Kochera, A. [Accessed August 25, 2015] Falls among older persons and the role of the home: An analysis of cost, incidence, and potential savings from home modification. AARP Public Policy Institute Issue Brief #56. Mar. 2002 Available at: http://assets.aarp.org/rgcenter/il/ib56_falls.pdf
- Berg WP, Alessio HM, Mills EM, Tong C. Circumstances and consequences of falls in independent community-dwelling older adults. *Age Ageing.* 1997; 26:261–8. [PubMed: 9271288]
- Stevens JA, Mahoney JE, Ehrenreich H. Circumstances and outcomes of falls among high risk community-dwelling older adults. *Inj Epidemiol.* 2014; 1:1–17. [PubMed: 27747675]
- Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev.* 2012; 9:CD007146.
- Black AA, Wood JM, Lovie-Kitchin JE. Inferior field loss increases rate of falls in older adults with glaucoma. *Optom Vis Sci.* 2011; 88:1275–82. [PubMed: 21873923]
- Haymes SA, LeBlanc RP, Nicolela MT, et al. Risk of falls and motor vehicle collisions in glaucoma. *Invest Ophthalmol Vis Sci.* 2007; 48:1149–55. [PubMed: 17325158]
- Lamoreux EL, Chong E, Wang JJ, et al. Visual impairment, causes of vision loss, and falls: The Singapore Malay Eye Study. *Invest Ophthalmol Vis Sci.* 2008; 49:528–33. [PubMed: 18234995]
- Ivers RQ, Cumming RG, Mitchell P, Attebo K. Visual impairment and falls in older adults: the Blue Mountains Eye Study. *J Am Geriatr Soc.* 1998; 46:58–64. [PubMed: 9434666]
- Klein BE, Klein R, Lee KE, Cruickshanks KJ. Performance-based and self-assessed measures of visual function as related to history of falls, hip fractures, and measured gait time: The Beaver Dam Eye Study. *Ophthalmology.* 1998; 105:160–4. [PubMed: 9442793]
- Freeman EE, Munoz B, Rubin G, West SK. Visual field loss increases the risk of falls in older adults: the Salisbury Eye Evaluation. *Invest Ophthalmol Vis Sci.* 2007; 48:4445–50. [PubMed: 17898264]
- de Boer MR, Pluijm SM, Lips P, et al. Different aspects of visual impairment as risk factors for falls and fractures in older men and women. *J Bone Miner Res.* 2004; 19:1539–47. [PubMed: 15312256]

18. Yuki K, Asaoka R, Tsubota K. Investigating the influence of visual function and systemic risk factors on falls and injurious falls in glaucoma using the structural equation modeling. *PLoS One*. 2015; 10:e0129316. [PubMed: 26053502]
19. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. *Br J Ophthalmol*. 2006; 90:262–7. [PubMed: 16488940]
20. Ramulu P. Glaucoma and disability: which tasks are affected, and at what stage of disease? *Curr Opin Ophthalmol*. 2009; 20:92–8. [PubMed: 19240541]
21. Ramulu PY, van Landingham SW, Massof RW, et al. Fear of falling and visual field loss from glaucoma. *Ophthalmology*. 2012; 119:1352–8. [PubMed: 22480738]
22. Ramulu PY, Hochberg C, Maul EA, et al. Glaucomatous visual field loss associated with less travel from home. *Optom Vis Sci*. 2014; 91:187–93. [PubMed: 24374635]
23. Gitlin LN, Schinfeld S, Winter L, et al. Evaluating home environments of persons with dementia: interrater reliability and validity of the Home Environmental Assessment Protocol (HEAP). *Disability and Rehabilitation*. 2002; 24:59–71. [PubMed: 11827156]
24. Mackenzie L, Byles J, Higginbotham N. Reliability of the Home Falls and Accidents Screening Tool (HOME FAST) for identifying older people at increased risk of falls. *Disability and Rehabilitation*. 2002; 24:266–74. [PubMed: 12004972]
25. Letts L, Scott S, Burtney J, et al. The reliability and validity of the safety assessment of function and the environment for rehabilitation (SAFER tool). *Br J Occup Ther*. 1998; 61:127–32.
26. Clemson L, Fitzgerald MH, Heard R. Content validity of an assessment tool to identify home fall hazards: the Westmead Home Safety Assessment. *Br J Occup Ther*. 1999; 62:171–9.
27. Tomita MR, Saharan S, Rajendran S, et al. Psychometrics of the Home Safety Self-Assessment Tool (HSSAT) to prevent falls in community-dwelling older adults. *Am J Occup Ther*. 2014; 68:711–8. [PubMed: 25397766]
28. Barstow BA, Bennett DK, Vogtle LK. Perspectives on home safety: do home safety assessments address the concerns of clients with vision loss? *Am J Occup Ther*. 2011; 65:635–42. [PubMed: 22214107]
29. Bhorade AM, Perlmuter MS, Wilson B, et al. Differences in vision between clinic and home and the effect of lighting in older adults with and without glaucoma. *JAMA Ophthalmol*. 2013; 131:1554–62. [PubMed: 24263699]
30. Donoghue OA, Ryan H, Duggan E, et al. Relationship between fear of falling and mobility varies with visual function among older adults. *Geriatr Gerontol Int*. 2014; 14:827–36. [PubMed: 24215140]
31. Connell BR, Wolf SL. Environmental and behavioral circumstances associated with falls at home among healthy elderly individuals. *Arch Phys Med Rehabil*. 1997; 78:179–86. [PubMed: 9041900]
32. Brooke-Wavell K, Perrett LK, Howarth PA, Haslam RA. Influence of the visual environment on postural stability in healthy older women. *Gerontology*. 2002; 48:293–7. [PubMed: 12169794]
33. Bailey IL, Bullimore MA, Raasch TW, Taylor HR. Clinical grading and effects of scaling. *Invest Ophthalmol Vis Sci*. 1991; 32:422–32. [PubMed: 1993595]
34. Crabb DP, Viswanathan AC. Integrated visual fields: a new approach to measuring the binocular field of view and visual disability. *Graefes Arch Clin Exp Ophthalmol*. 2005; 243:210–6. [PubMed: 15806374]
35. Asaoka R, Crabb DP, Yamashita, et al. Patients have two eyes!: binocular versus better eye visual field indices. *Invest Ophthalmol Vis Sci*. 2011; 52:7007–11. [PubMed: 21810985]
36. Hodapp, E., Parrish, RK., Anderson, DR. *Clinical decisions in glaucoma*. St. Louis, MO: The CV Mosby Co; 1993. p. 52-61.
37. Ramulu PY, Maul E, Hochberg C, et al. Real-world assessment of physical activity in glaucoma using an accelerometer. *Ophthalmology*. 2012; 119:1159–66. [PubMed: 22386950]
38. Montorio I, Izal M. The Geriatric Depression Scale: a review of its development and utility. *Int Psychogeriatr*. 1996; 8:103–12.
39. Busse A, Sonntag A, Bischof J, et al. Adaptation of dementia screening for vision-impaired older persons: administration of the Mini-Mental State Examination. *J Clin Epidemiol*. 2002; 55:909–15. [PubMed: 12393079]

40. United States Census Bureau. [Accessed June 8, 2016] American FactFinder - Community Facts. Available at: http://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml
41. United States Department of Justice. [Accessed August 31, 2015] 2010 Americans with Disabilities Act (ADA) Standards for Accessible Design. Available at: <https://www.access-board.gov/attachments/article/983/ADASTandards.pdf>
42. International Code Council. [Accessed August 31, 2015] International Residential Code for One- and Two-Family Dwellings. Available at: <http://publicecodes.cyberregs.com/icod/irc/2012/index.htm>
43. Figueiro, MG. Lighting the way: A key to independence, 2001. Lighting Research Center at Rensselaer Polytechnic Institute and the AARP Andrus Foundation; Available at: <http://www.lrc.rpi.edu/programs/lighthealth/aarp/pdf/aarpbook3.pdf> [Accessed August 31, 2015]
44. Illuminating Engineering Society of North America. Recommended practice for lighting and the visual environment for senior living. New York: IESNA; 1998.
45. Crabb DP, Smith ND, Glen FC, et al. How does glaucoma look?: patient perception of visual field loss. *Ophthalmology*. 2013; 120:1120–6. [PubMed: 23415421]
46. Gill TM, Williams CS, Robison JT, Tinetti ME. A population-based study of environmental hazards in the homes of older persons. *Am J Public Health*. 1999; 89:553–6. [PubMed: 10191800]
47. Carter SE, Campbell EM, Sanson-Fisher RW, et al. Environmental hazards in the homes of older people. *Age Ageing*. 1997; 26:195–202. [PubMed: 9223715]
48. Huang TT. Home environment hazards among community-dwelling elderly persons in Taiwan. *J Nurs Res*. 2005; 13:49–57. [PubMed: 15977135]
49. Leclerc BS, Begin C, Cadieux E, et al. Relationship between home hazards and falling among community-dwelling seniors using home-care services. *Rev Epidemiol Sante Publique*. 2010; 58:3–11. [PubMed: 20097025]
50. Lowery K, Buri H, Ballard C. What is the prevalence of environmental hazards in the homes of dementia sufferers and are they associated with falls. *Int J Geriatr Psychiatry*. 2000; 15:883–6. [PubMed: 11044868]
51. Clemson L, Cumming RG, Roland M. Case-control study of hazards in the home and risk of falls and hip fractures. *Age Ageing*. 1996; 25:97–101. [PubMed: 8670535]
52. Gill TM, Williams CS, Tinetti ME. Environmental hazards and the risk of nonsyncopal falls in the homes of community-living older persons. *Med Care*. 2000; 38:1174–83. [PubMed: 11186296]
53. Dong X, Simon MA, Evans DA. Prevalence of self-neglect across gender, race, and socioeconomic status: findings from the Chicago Health and Aging Project. *Gerontology*. 2012; 58:258–68. [PubMed: 22189358]
54. Cullinan TR, Silver JH, Gould ES, Irvine D. Visual disability and home lighting. *Lancet*. 1979; 1:642–4. [PubMed: 85874]
55. Bakker R, Iofel Y, Lachs MS. Lighting levels in the dwellings of homebound older adults. *J Hous Elderly*. 2004; 18:17–27.
56. Brunnstrom G, Sorensen S, Alsterstad K, Sjostrand J. Quality of light and quality of life – the effect of lighting adaptation among people with low vision. *Ophthalmic Physiol Opt*. 2004; 24:274–80. [PubMed: 15228504]

Figure 1.

Hazard prevalence and percent change in lighting by room. Percentage of graded items was calculated as the number of identified hazards divided by the total number of items present in that room. The bathroom was used as the reference group in the generalized estimating equation model for lighting differences between rooms.

Figure 2.

Mean number of room hazards by integrated visual field (IVF) sensitivity. Error bars represent 95% confidence intervals. Normal/near-normal IVF: >28 dB; mild-moderate IVF loss: 23–28 dB; severe IVF loss: <23 dB. Normal IVF sensitivity is approximately 31 dB.

Figure 3.

Mean intensity of room lighting by integrated visual field (IVF) sensitivity. Dotted line represents the minimum recommended ambient light intensity (300 lux). Normal/near-normal IVF: >28 dB; mild-moderate IVF loss: 23–28 dB; severe IVF loss: <23 dB. Normal IVF sensitivity is approximately 31 dB. $P>0.05$ for log lighting comparisons across groups in all rooms.

Table 1

Rooms in which items were graded, and criteria by which items were identified as a hazard.

Item class	Item definition	Bathroom	Bedroom	Dining rm.	Entryway	Hallway	Kitchen	Living rm.	Stairs
Handrails	Number of handrails (hazard if < 2)				X				X
	Loose handrails				X				X
	Portion of stairs without handrail				X				X
	Handrail perimeter (hazard if < 4 or > 6.25")				X				X
Floors	No grab bars in tub/shower	X							
	No grab bars at toilet	X							
	Sloped ground on sidewalk				X				
	Uneven dirt path on sidewalk				X				
	Loose external steps				X				
	Cracked external steps				X				
	Sloping external steps				X				
	Height of stair riser (hazard if < 4 or > 7.75")				X				X
	Depth of stair treads (hazard if < 10")				X				X
	Height of front step riser (hazard if < 4 or > 7.75")				X				
	Smooth finish (no traction)				X				X
	Glossy or shiny finish	X	X	X		X	X	X	X
	Friction coefficient (hazard if < 0.6)	X	X	X	X	X	X	X	X
	Landing only on one side of doorway				X				
	Landing more narrow than doorway				X				
	Landing < 36 inches				X				
Floors	Width of doorway (hazard if < 32 or > 48")				X				
	Width of stairway (hazard if < 36")				X				X
	Width of hallway (hazard if < 36")					X			
	Height of door threshold (hazard if > 0.5")	X	X	X	X	X	X	X	
	No contrast between door threshold and floor	X	X	X		X	X	X	
	Frayed/torn/folded carpeting	X	X	X		X	X	X	
	Unsecured rugs; rugs with curling edges	X	X	X		X	X	X	

Item class	Item definition	Bathroom	Bedroom	Dining rm.	Entryway	Hallway	Kitchen	Living rm.	Stairs
	No contrast between floors and fixtures	X							
	Floor covered with objects/clutter (hazard if > 50%)	X	X	X		X	X	X	
	No bathmat/non-skid strips in bathtub/shower	X							
	No non-skid rug/mat outside bathtub/shower	X							
Lighting	Ambient light (hazard if < 300 lux)	X	X	X	X	X	X	X	X
	Area not illuminated by light fixture/missing fixture				X				X
	Broken light fixture/missing bulbs				X				X
	Windows without sheer coverings	X	X	X		X	X	X	X
	Exposed light bulbs	X	X	X		X	X	X	X
	Light switches only accessible from fully inside room	X	X	X		X	X	X	
	Shadows on stairway				X				X
	Number of light switches for stairs (hazard if < 2)								X
	Switch required to turn on exterior light				X				
	No light in bathtub/shower with curtains closed	X							
Furniture	Unstable furniture		X	X			X	X	
	Seats without arm rests		X	X			X	X	
	Glossy/shiny finish of countertop						X		
Other	Inability to reach microwave with both feet on floor						X		
	No handle on step stool		X				X		
Total items: 46		Total hazards: 127							

Table 2

Baseline characteristics of subjects participating in and declining the home assessment.

Variable	Participants (n = 174)	Non-participants (n = 71) ¹	P-value
Age, years, mean (SD)	71.1 (7.57)	69.5 (7.48)	0.09
Male sex, n (%)	94 (54.0%)	32 (45.1%)	0.20
Race, n (%)			0.85
White	107 (61.5%)	46 (64.8%)	
African-American	52 (29.9%)	18 (25.4%)	
Asian/Pacific-Islander	9 (5.2%)	5 (7.0%)	
Other	6 (3.5%)	2 (2.8%)	
Highest level of education completed, n (%)			0.51
Less than high school	7 (4.0%)	1 (1.4%)	
High school	18 (10.3%)	11 (15.5%)	
Some college or 2-year college	22 (12.6%)	11 (15.5%)	
4-year college	45 (25.9%)	14 (19.7%)	
Master's or Doctorate program	82 (47.1%)	34 (47.9%)	
Lives alone, n (%)	33 (19.0%)	16 (22.5%)	0.53
Married, n (%)	106 (60.9%)	47 (66.2%)	0.44
Has pets in home, n (%)	57 (33.0%)	24 (33.8%)	0.90
Employed, n (%)	57 (32.8%)	30 (42.3%)	0.16
Income, median, dollars (IQR) ²	88,041 (64,459–106,006)	88,208 (65,909–106,006)	0.76
Number of prescription medications, mean (SD) ³	4.4 (3.2)	5.1 (3.2)	0.10
MMSE-blind score, mean (SD) ⁴	20.2 (1.6)	20.0 (1.6)	0.32
Depression, n (%)	4 (2.3%)	4 (5.7%)	0.18
Medical comorbidities, mean (SD)	2.2 (1.6)	2.5 (1.7)	0.26
Diagnosis			
Primary open angle glaucoma	110 (63.2%)	47 (66.2%)	0.96
Primary angle closure glaucoma	13 (7.5%)	4 (5.6%)	
Pseudoexfoliation glaucoma	10 (5.8%)	3 (4.2%)	
Pigmentary glaucoma	2 (1.2%)	1 (1.4%)	
Glaucoma suspect	39 (22.4%)	16 (22.5%)	
Use of assistive device at home ⁵	10 (5.7%)		
Dwelling type, n (%)			
House	141 (81.0%)		
Apartment	33 (19.0%)		
Housing status, n (%)			
Own	159 (91.9%)		
Rent	14 (8.1%)		
Number of floors, mean (SD)	2.39 (0.93)		

Variable	Participants (n = 174)	Non-participants (n = 71) ¹	P-value
Number of rooms assessed, mean (SD)	6.99 (0.83)		
Better-eye VF MD, dB, mean (SD) ⁶	-4.4 (6.18)	-5.0 (7.56)	0.77
Worse-eye VF MD, dB, mean (SD) ⁷	-8.7 (8.20)	-7.9 (7.61)	0.67
Integrated VF sensitivity, dB, mean (SD)	27.2 (4.00)	26.9 (5.16)	0.79
LogMAR visual acuity, better eye, mean (SD)	0.11 (0.27)	0.08 (0.13)	0.81
LogCS MARS, binocular, mean (SD)	1.66 (0.22)	1.64 (0.27)	0.61

SD = standard deviation; IQR = interquartile range; MMSE-blind = Mini-Mental State Examination for the visually impaired; VF = visual field; MD = mean deviation; logMAR = logarithm of the minimum angle of resolution; logCS = logarithm contrast sensitivity

¹ Home data not available for non-participants.

² Median income by zip code taken from 2010–2014 American Community Survey 5-Year Estimates.

³ Excludes over-the-counter medications.

⁴ Maximum score of 22.

⁵ Cane, walking stick, wheelchair.

⁶ Data available for 173 participants and 68 non-participants; includes patients with only one eye tested.

⁷ Data available for 168 participants and 62 non-participants.

Table 3

Numbers of hazards identified in each room and the full home.

Room	N ¹	Maximum possible items	Mean number of graded items (SD)	Mean number of identified hazards (SD)	Percentage of graded items identified as hazards
Bathroom	172	17	14.5 (1.2)	7.9 (2.0)	54.1%
Dining room	152	13	9.4 (1.1)	4.0 (1.3)	42.6%
Stairs	135	17	16.0 (1.0)	6.5 (1.7)	40.7%
Living room	90	13	9.8 (1.1)	3.5 (1.4)	35.7%
Bedroom	168	14	10.0 (1.2)	3.3 (1.5)	32.8%
Kitchen	172	16	12.1 (1.5)	4.2 (2.0)	34.4%
Entryway	174	25	16.6 (6.6)	4.8 (2.7)	28.4%
Hallway	153	12	7.9 (0.7)	2.7 (1.2)	34.4%
Entire home	174	127	85.17 (13.23)	32.70 (7.58)	38.32% ²

¹ N refers to number of homes in which the room was graded.

² Hazards in rooms that were not evaluated were not included in the denominator for the percentage calculation.

Table 4

Percentage of hazards among graded items, and number of homes containing each hazard.

Item	No. of homes in which item graded	Mean no. of rooms in which item graded (range)	Mean no. of rooms in which hazard present (SD) ¹	Percentage of hazard among graded items ²	Homes with hazard in at least 1 room, n (%) ³
Handrails					
No grab bars at toilet	172	0.99 (0–1)	0.91 (0.29)	91.9%	158 (90.8%)
No grab bars in tub/shower	172	0.99 (0–1)	0.78 (0.41)	79.1%	136 (78.2%)
Fewer than 2 handrails	148	1.41 (0–2)	1.10 (0.78)	78.0%	129 (74.1%)
Portion of stairs without handrail	145	1.37 (0–2)	0.38 (0.56)	27.6%	59 (33.9%)
Loose handrails	140	1.14 (0–2)	0.26 (0.48)	23.1%	43 (24.7%)
Handrail perimeter < 4 or > 6.25 inches	140	1.15 (0–2)	0.20 (0.43)	17.0%	32 (18.4%)
Floors					
Height of door threshold > 0.5 inches	166	2.22 (0–5)	1.64 (1.14)	73.9%	147 (84.5%)
No bathmat/non-skid strips in bathtub/shower	167	0.96 (0–1)	0.82 (0.38)	85.6%	143 (82.2%)
No non-skid rug/mat outside bathtub/shower	167	0.96 (0–1)	0.82 (0.39)	85.0%	142 (81.6%)
Depth of stair treads < 10 inches	147	1.43 (0–2)	1.01 (0.74)	71.0%	127 (73.0%)
Unsecured rugs; rugs with curling edges	165	2.55 (0–6)	1.22 (1.05)	47.9%	124 (71.3%)
Width of stairway < 36 inches	148	1.43 (0–2)	0.66 (0.62)	46.0%	100 (57.5%)
Friction coefficient < 0.6	125	2.47 (0–7)	1.60 (1.80)	64.7%	94 (54.0%)
No contrast between door threshold and floor	134	1.45 (0–4)	0.86 (0.97)	59.1%	94 (54.0%)
Height of stair riser < 4 or > 7.75 inches	147	1.43 (0–2)	0.61 (0.65)	42.6%	90 (51.7%)
No contrast between floors and fixtures	170	0.98 (0–1)	0.50 (0.50)	51.2%	87 (50.0%)
Glossy or shiny finish	174	5.91 (3–7)	0.91 (1.35)	15.4%	75 (43.1%)
Width of doorway < 32 or > 48 inches	170	0.98 (0–1)	0.33 (0.47)	34.1%	58 (33.3%)
Width of hallway < 36 inches	153	0.88 (0–1)	0.32 (0.47)	35.9%	55 (31.6%)
Sloped ground on public sidewalk	101	0.58 (0–1)	0.24 (0.43)	41.6%	42 (24.1%)
Height of front step riser < 4 or > 7.75 inches	129	0.74 (0–1)	0.21 (0.41)	28.7%	37 (21.3%)
Uneven dirt path on public sidewalk	101	0.58 (0–1)	0.18 (0.38)	30.7%	31 (17.8%)
Floor covered with > 50% clutter	174	5.18 (3–6)	0.27 (0.71)	5.2%	28 (16.1%)

Item	No. of homes in which item graded	Mean no. of rooms in which item graded (range)	Mean no. of rooms in which hazard present (SD) ¹	Percentage of hazard among graded items ²	Homes with hazard in at least 1 room, n (%) ³
Frayed/torn/folded carpeting	137	1.50 (0–4)	0.16 (0.52)	10.7%	19 (10.9%)
Smooth finish (no traction)	150	1.41 (0–2)	0.07 (0.25)	4.9%	12 (6.9%)
Width of landing < 36 inches	106	0.61 (0–1)	0.04 (0.20)	6.6%	7 (4.0%)
Cracked external steps	116	0.67 (0–1)	0.03 (0.17)	4.3%	5 (2.9%)
Sloping external steps	116	0.67 (0–1)	0.03 (0.17)	4.3%	5 (2.9%)
Landing only on one side of doorway	109	0.63 (0–1)	0.02 (0.15)	3.7%	4 (2.3%)
Landing more narrow than doorway	108	0.62 (0–1)	0.02 (0.13)	2.8%	3 (1.7%)
Loose external steps	116	0.67 (0–1)	0.01 (0.11)	1.7%	2 (1.1%)
Lighting					
Ambient light < 300 lux	172	6.14 (0–8)	4.43 (1.51)	72.1%	172 (98.9%)
Exposed light bulbs	174	5.90 (4–7)	3.28 (1.59)	55.6%	167 (96.0%)
Windows without sheer coverings	174	5.98 (4–7)	2.70 (1.90)	45.1%	142 (81.6%)
No light in bathtub/shower with curtains closed	171	0.98 (0–1)	0.67 (0.47)	67.8%	116 (66.7%)
Shadows on stairway	147	1.45 (0–2)	0.72 (0.63)	50.0%	109 (62.6%)
Light switches only accessible from fully inside room	174	5.16 (3–6)	0.86 (0.92)	16.6%	99 (56.9%)
Switch required to turn on exterior light	168	0.97 (0–1)	0.46 (0.50)	47.6%	80 (46.0%)
Area not illuminated by light fixture/missing fixture	173	1.77 (0–2)	0.34 (0.50)	19.5%	58 (33.3%)
Broken light fixture/missing bulbs	173	1.71 (0–2)	0.14 (0.36)	8.1%	23 (13.2%)
Fewer than 2 light switches for stairs	129	0.74 (0–1)	0.07 (0.26)	10.1%	13 (7.5%)
Furniture					
Seats without arm rests	174	3.27 (2–4)	1.31 (0.88)	40.1%	146 (83.9%)
Unstable furniture	173	2.69 (0–4)	0.65 (0.74)	24.1%	88 (50.6%)
Glossy/shiny finish of countertop	172	0.99 (0–1)	0.39 (0.49)	39.0%	67 (38.5%)
Other					
No handle on step stool	153	1.46 (0–2)	0.48 (0.64)	33.1%	70 (40.2%)
Inability to reach microwave with both feet on floor	170	0.98 (0–1)	0.01 (0.08)	0.6%	1 (0.6%)

Values presented in bold indicate notable results (>75%).

¹Items graded as “Yes” defined as a hazard

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

² Hazards relating to home items or rooms that were not present (marked as "Not assessed") were not included in the denominator for the percentage calculation.

³ Percentage of 174.

Table 5

Number and percentage of homes containing items graded as hazardous within each room.

Item	Entryway	Living room	Dining room	Kitchen	Stairs	Hallway	Bedroom	Bathroom
Handrails								
Fewer than 2 handrails	90/113 79.6%	—	—	—	101/132 76.5%	—	—	—
Loose handrails	18/69 26.1%	—	—	—	28/130 21.5%	—	—	—
Portion of stairs without handrail	42/106 39.6%	—	—	—	24/133 18.0%	—	—	—
Handrail perimeter < 4 or > 6.25 inches	9/70 12.9%	—	—	—	25/130 19.2%	—	—	—
No grab bars in tub/shower	—	—	—	—	—	—	—	136/172 79.1%
No grab bars at toilet	—	—	—	—	—	—	—	158/172 91.9%
Floors								
Sloped ground on public sidewalk	42/101 41.6%	—	—	—	—	—	—	—
Uneven dirt path on public sidewalk	31/101 30.7%	—	—	—	—	—	—	—
Loose external steps	2/116 1.7%	—	—	—	—	—	—	—
Cracked external steps	5/116 4.3%	—	—	—	—	—	—	—
Sloping external steps	5/116 4.3%	—	—	—	—	—	—	—
Height of stair riser < 4 or > 7.75 inches	44/116 37.9%	—	—	—	62/133 46.6%	—	—	—
Depth of stair treads < 10 inches	98/113 86.7%	—	—	—	78/135 57.8%	—	—	—
Height of front step riser < 4 or > 7.75 inches	37/129 28.7%	—	—	—	—	—	—	—
Smooth finish (no traction)	8/114 7.0%	—	—	—	4/132 3.0%	—	—	—
Glossy or shiny finish	—	16/89 18.0%	26/150 17.3%	33/172 19.2%	15/135 11.1%	25/152 16.4%	15/158 9.5%	28/172 16.3%

Item	Entryway	Living room	Dining room	Kitchen	Stairs	Hallway	Bedroom	Bathroom
Friction coefficient < 0.6	4/4 100.0%	16/31 51.6%	54/91 59.3%	67/113 59.3%	22/30 73.3%	28/42 66.7%	29/36 80.6%	58/83 69.9%
Landing only on one side of doorway	4/109 3.7%	—	—	—	—	—	—	—
Landing more narrow than doorway	3/108 2.8%	—	—	—	—	—	—	—
Width of landing < 36 inches	7/106 6.6%	—	—	—	—	—	—	—
Width of doorway < 32 or > 48 inches	58/170 34.1%	—	—	—	—	—	—	—
Width of stairway < 36 inches	21/113 18.6%	—	—	—	93/135 68.9%	—	—	—
Width of hallway < 36 inches	—	—	—	—	—	55/153 35.9%	—	—
Height of door threshold > 0.5 inches	133/150 88.7%	11/13 84.6%	21/30 70.0%	30/52 57.7%	—	4/6 66.7%	15/22 68.2%	72/114 63.2%
No contrast between door threshold and floor	—	11/17 64.7%	22/33 66.7%	34/54 63.0%	—	4/8 50.0%	13/24 54.2%	65/116 56.0%
Frayed/torn/folded carpeting	—	9/48 18.8%	2/22 9.1%	1/7 14.3%	—	3/67 4.5%	12/106 11.3%	1/11 9.1%
Unsecured rugs; rugs with curling edges	—	20/66 30.3%	15/50 30.0%	48/98 49.0%	—	18/33 54.5%	36/65 55.4%	75/131 57.3%
No contrast between floors and fixtures	—	—	—	—	—	—	—	87/170 51.2%
Floor covered with > 50% clutter	—	6/89 6.7%	6/150 4.0%	3/171 1.8%	—	4/153 2.6%	25/167 15.0%	3/171 1.8%
No bathmat/non-skid strips in bathtub/shower	—	—	—	—	—	—	—	143/167 85.6%
No non-skid rug/mat outside bathtub/shower	—	—	—	—	—	—	—	142/167 85.0%
Lighting								
Ambient light < 300 lux	48/53 90.6%	73/88 83.0%	77/150 51.3%	100/169 59.2%	114/130 87.7%	136/149 91.3%	147/163 90.2%	75/166 45.2%
Area not illuminated by light fixture/missing fixture	4/173 2.3%	—	—	—	56/135 41.5%	—	—	—
Broken light fixture/missing bulbs	10/169 5.9%	—	—	—	14/128 10.9%	—	—	—

Item	Entryway	Living room	Dining room	Kitchen	Stairs	Hallway	Bedroom	Bathroom
Windows without sheer coverings	—	51/90 56.7%	93/152 61.2%	95/172 55.2%	68/135 50.4%	52/152 34.2%	62/168 36.9%	49/172 28.5%
Exposed light bulbs	—	32/87 36.8%	101/152 66.4%	103/172 59.9%	62/126 49.2%	73/150 48.7%	69/168 41.1%	131/172 76.2%
Light switches only accessible from fully inside room	—	40/86 46.5%	24/151 15.9%	10/172 5.8%	.	16/148 10.8%	43/168 25.6%	16/172 9.3%
Shadows on stairway	31/118 26.3%	—	—	—	95/134 70.9%	—	—	—
Fewer than 2 light switches for stairs	—	—	—	—	13/129 10.1%	—	—	—
Switch required to turn on exterior light	80/168 47.6%	—	—	—	—	—	—	—
No light in bathtub/shower with curtains closed	—	—	—	—	—	—	—	116/171 67.8%
Furniture								
Unstable furniture	—	22/89 24.7%	33/142 23.2%	25/83 30.1%	—	—	33/154 21.4%	—
Seats without arm rests	—	10/90 11.1%	133/151 88.1%	44/161 27.3%	—	—	41/167 24.6%	—
Glossy/shiny finish of countertop	—	—	—	67/172 39.0%	—	—	—	—
Other								
Inability to reach microwave with both feet on floor	—	—	—	1/170 0.6%	—	—	—	—
No handle on step stool	—	—	—	68/137 49.6%	—	—	16/117 13.7%	—

Values presented in bold indicate notable results (>75%).

Table 6

Person- and room-based features influencing lighting levels, multivariate model.

Variable	Interval	Percent change in lighting (lux) ^I	Confidence interval ^I	P-value
IVF total sensitivity, dB	5 dB lower	1.1%	-11.5 to 15.5%	0.87
LogCS MARS, binocular	0.1 logCS lower	3.4%	-1.6 to 8.6%	0.18
LogMAR VA, better eye	0.1 logMAR lower	-1.7%	-5.5 to 2.2%	0.39
Age	5 years older	-4.3%	-10.7 to 2.5%	0.21
African-American	vs. White/Asian	-17.8%	-35.4 to 4.7%	0.11
Male	vs. Female	-7.4%	-24.9 to 14.1%	0.47
Median income	\$10,000 higher	5.7%	2.6 to 8.9%	<0.001
Room				
Stairs	vs. Bathroom	-86.0%	-89.2 to -81.7%	<0.001
Hallway	vs. Bathroom	-85.9%	-89.1 to -81.8%	<0.001
Bedroom	vs. Bathroom	-70.9%	-77.3 to -62.8%	<0.001
Entryway	vs. Bathroom	-69.1%	-78.5 to -55.5%	<0.001
Living room	vs. Bathroom	-57.2%	-68.2 to -42.3%	<0.001
Kitchen	vs. Bathroom	-21.2%	-38.3 to 0.6%	0.06
Dining room	vs. Bathroom	-5.8%	-26.8 to 21.3%	0.65

IVF = integrated visual field; logCS = logarithm contrast sensitivity; logMAR = logarithm of the minimum angle of resolution; VA = visual acuity

Values presented in bold indicate significant results. Values relating to demographic and room information are taken from the IVF sensitivity model.

^I Calculated as $-(1-10^x)$, where x is the variable coefficient or CI upper/lower limit in the model

Table 7

Room- and item category-based features influencing the likelihood of individual items being graded as hazardous.

Variable	Interval	Odds ratio	Confidence interval	P-value
Room				
Bathroom	vs. Entryway	2.75	2.45 – 3.08	<0.001
Dining room	vs. Entryway	1.82	1.59 – 2.09	<0.001
Kitchen	vs. Entryway	1.49	1.31 – 1.70	<0.001
Living room	vs. Entryway	1.40	1.18 – 1.65	<0.001
Stairs	vs. Entryway	1.39	1.23 – 1.57	<0.001
Bedroom	vs. Entryway	1.26	1.09 – 1.44	0.001
Hallway	vs. Entryway	1.24	1.07 – 1.44	0.004
Category				
Handrails	vs. Floors	2.06	1.81 – 2.35	<0.001
Lighting	vs. Floors	1.57	1.46 – 1.70	<0.001
Furniture	vs. Floors	1.03	0.89 – 1.18	0.73
Other	vs. Floors	0.52	0.41 – 0.68	<0.001

Values presented in bold indicate significant results.