HEALTHY AGING RESEARCH

Outdoor hazards and falls among community-dwelling older Australians

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Abstract

Background: Falls occur in approximately one-third of older Australians per year and can be attributed to intrinsic or extrinsic factors, but are often reported by the elderly to be associated with the latter: environmental hazards. The objective of this study was to investigate outdoor falls and their relationship with outdoor hazards among community-dwelling older people in the City of Sydney.

Methods: Focus group discussions (n=47) and structured interviews (n=124) were conducted among Sydney residents aged 60 years and older to explore issues regarding their residential environments and health outcomes. Structured interviews addressed experiences of indoor and outdoor falls and near falls, and participants' perception of hazards in their outdoor environment.

Results: The focus groups suggested that outdoor falls are common and are associated with insufficient street lighting, uneven road/path surfaces, tree roots, and fallen seed pods from Plane trees. In the survey, 35.5% of participants reported an outdoor fall or near fall. Poisson regression analysis, while accounting for other potential predictors, demonstrated that the risk of an outdoor fall or near fall was higher for footpaths of lower perceived quality and a non-Asian ethnic background.

Conclusions: Outdoor falls are a substantial problem among community-dwelling older Australians and outdoor hazards may contribute to these falls. Future fall prevention interventions should evaluate whether modification of the outdoor environment reduces outdoor falls.

Introduction

Falls affect approximately one-third of community-dwelling older Australians annually [1]. Falls are believed to occur as a result of either intrinsic factors (e.g. poor vision, poor balance, medication use,

alcohol use) or extrinsic factors (e.g. environmental hazards). Older people often attribute their falls to environmental hazards [2].

Much research has investigated the role of environmental hazards in precipitating falls within the

home [3-7] and suggests that a complex interaction between the presence of home hazards (such as stairs, rugs, poor lighting and slippery surfaces) and an older person's physical abilities contributes to falling [7,8]. Home hazards appear to increase the risk of falls among older people without a preceding history of falling [9], and among vigorous older people, for whom intrinsic factors may be less likely to contribute to falls [7,10].

Studies in various countries, including Australia, the United Kingdom, United States of America, Canada and China, report that between 52-63% of falls among older people occur outdoors [7-8,11-14]. Although older people are more likely to attribute outdoor falls to environmental causes compared with indoor falls [2,14], little is known about the relationship between outdoor environmental hazards and falls. A Northern Californian study among middle aged and older adults identified footpaths, curbs and streets as the most common locations of outdoor falls; in approximately 75% of outdoor falls, participants self-reported that four specific environmental causes (uneven surface, wet surface, tripping on an object, slipping on an object) were involved [14]. These findings were supported by a study conducted among healthy older women in Melbourne [12], which identified streets, parks, steps, curbs and public transport as frequent locations for outdoor falls, but did not report on the relationship between hazards and falls.

This paper focuses on the relationship between reported footpath quality and falls among community-dwelling older Australians employing data collected as a part of the "Ageing Well in Australian Cities" study.

Methods

Selection of areas and participants

Five areas within the City of Sydney (CoS) were chosen due to the high number of independently living older people, services for older people through which to recruit participants, a range of socioeconomic levels, and data relating to housing and the residential environment (necessary for other aspects of the "Ageing Well in Australian Cities" study).

All participants were independently-living residents of these areas aged 60 years and older. Participants received an information statement assuring them of anonymity, confidentiality and the right to withdraw, with a contact number for further details. Ethical approval for all aspects of the study was granted by the University of New South Wales Human Research Ethics Committee.

Discussion groups

Participants and sampling

Older people who visited CoS community centres in the study areas were invited to participate in 6- to 9-person group discussions at the centres to discuss features of their local residential environment in return for a complimentary lunch. In two centres with a large number of Chinese members, group discussions were conducted in Mandarin. Of the 47 older people who attended the discussion groups, 74% were female, 64% were aged over 70, and 21% lived in detached housing.

Materials

Questions were designed to generate discussion surrounding the impact of the local area and housing on health, and to elicit specific information on key issues.

Procedure

Two researchers conducted each of the six focus groups at the community centres. Discussions lasted approximately 1.5 hours. After the main points of the participant information statement were outlined and consent was given, discussions were conducted and recorded. The Mandarin recordings were transcribed and translated.

Survey

Participants and sampling

Because we were not permitted to access electoral roles, we recruited a convenience sample of 83 participants through CoS community centres, Meals

on Wheels, newspaper advertisements, and flyer distribution in the study areas. The study was promoted as one investigating the relationship between residential environment and health and involving a 1.5 hour interview in the home or community centre with completion of a checklist of relevant home features by an independent surveyor. The response rate for this sub-sample cannot be calculated. A further 41 participants were recruited by a market research company that has access to electoral roles; the company telephoned randomly-selected residents fitting the selection criteria to organise the interview in their homes. The response rate for this sub-sample was greater than 60%. The primary reason for refusal to participate was the duration of the survey and privacy concerns. Participants received a $10 supermarket gift voucher for their contribution.

Each sub-sample represented each study area approximately evenly. Surveys were conducted in English (72.5%) and Chinese (Mandarin and Cantonese) (27.5%). The majority of participants were born in Australia (53.2%), followed by China (27.4%), the United Kingdom (5.6%), New Zealand (4.8%) and elsewhere (8.9%). The sample was 56.5% female and had a mean age of 71.78 years (range 60-92 years, median 71 years). The characteristics of the study population are presented in table 1.

Study outcome

To assess falls and near falls participants were asked "In the last two years how many...

- ... falls have you had indoors? Outdoors?(none, one, two or more)

- ... near falls have you had indoors? Outdoors? (none, one, two or more)

Near falls are included in analysis because they have been shown to be a good predictor of future falls [18, 19]. The survey instrument was modified after the first 83 participants responded to questions regarding falls or near falls without specification of indoors/outdoors. For these participants, we only obtained the location of 'the most recent fall or near fall'. People who had experienced at least one fall or near fall were asked the location (inside own home/building, inside other building, outside near the

home, or on the street), and the activity involved at the time of the most recent fall or near fall. These variables were employed to generate the dependent variable "ever fallen or nearly fallen outside" and the confounding variable previous fall history (i.e., "ever fallen or nearly fallen inside").

Independent variables of interest

Participants rated their agreement on a 1-5-point scale (from strongly disagree (1 point) to strongly agree (5 points)) with 9 statements regarding the quality of footpaths in their area adapted from several walkability checklists (e.g. http://www.goforyourlife.vic.gov.au) including: "There are enough footpaths provided in this area"; "The footpaths are wide enough for me"; "The general condition of the footpath is good"; "The footpaths have no protruding tree roots". We summed the total scores for these nine statements to produce a comprehensive "footpath quality" as the primary independent variable with a scale ranging from 9-45.

Information was also collected about personal and situational characteristics that have demonstrated relationships with falls [6]. These were ethnicity (assessed in terms of country of birth and categorised as Asian and non-Asian) due to findings that Asians have a lower hip fracture rates [20]), as well as age (later categorised into groups: ≤64, 65-69, 70-74, 75-79, or ≥80 years), gender; body mass index [BMI] (calculated from height and weight and categorised as <25 or ≥25, unclear vision in the past week (categorised as "never" or "at least sometimes"), physical handicap (scored as "present" if health was reported to limit any of 10 activities "a lot", and otherwise as "not present"), general health (measured using a single item and categorised as "excellent/very good", "good", or "fair/poor"), use of medication for insomnia or depression (categorised as "yes", "no", or "unknown"), alcohol use (dichotomized in "never" or "occasionally versus more than occasionally"), noise from cars, trains, neighbours, airplanes considered a serious problem in the neighbourhood (categorised as "yes" or "no"),and frequency of walking as a mode of transport in a normal week (categorised as walking <1, 1-6, or 7 days per week).

Table 1. Characteristics of the study population (n=124)

| | | Ever/Nearly fallen outside | |
| | | Yes | No |
		n=44 (100%)	n=80 (100%)
Footpath quality*	Mean (sd)	31.88 (5.42)	33.11 (6.18)
Previous fall history	Yes	13 (29.6)	25 (31.2)
	No	31 (70.4)	55 (68.8)
Ethnicity	Asian	20 (45.4)	46 (57.5)
	Non-Asian	24 (54.6)	34 (42.5)
Age	≤64	3 (6.8)	13 (16.3)
	65-69	12 (27.3)	24 (30.0)
	70-74	16 (36.4)	17 (21.2)
	75-79	5 (11.4)	15 (18.8)
	≥80	8 (18.2)	11 (13.7)
Gender	Female	25 (56.8)	45 (56.2)
	Male	19 (43.2)	35 (43.8)
BMI	<25	23 (52.3)	52 (65.0)
	≥25	21 (47.7)	28 (35.0)
Unclear vision in the past week	Never	26 (59.1)	56 (70.0)
	At least sometimes	18 (40.9)	24 (30.0)
Physical handicap	present	35 (79.6)	57 (71.3)
	not present	9 (20.4)	23 (28.7)
General health	Excellent/Very good	16 (36.4)	24 (30.0)
	Good	13 (29.5)	38 (47.5)
	Fair/Poor	15 (34.1)	18 (22.5)
Medication use for insomnia	Yes	10 (22.7)	3 (3.7)
	No	6 (13.6)	21 (26.3)
	Unknown	28 (63.6)	56 (70.0)
Medication use for depression	Yes	7 (15.9)	22 (27.5)
	No	7 (15.9)	9 (11.3)
	Unknown	30 (68.2)	49 (61.2)
Noise	Yes	15 (34.1)	21 (26.3)
	No	29 (65.9)	59 (73.7)
Alcohol use	More than occasional	16 (36.4)	24 (30.0)
	No or occasional	28 (63.6)	56 (70.0)
Frequency of walking per week	<1 day	2 (4.6)	12 (15.0)
	1-6 days	17 (38.6)	25 (31.3)
	7 days	25 (56.8)	43 (53.7)

Footpath quality was normally distributed (Kolmogorov-Smirnov test statistic=0.08, p>0.05)

Statistical analysis

Relative risk of ever having fallen or nearly fallen outdoors was estimated for footpath quality and various personal characteristics using Poisson regressions with scaled deviance parameters [21, 22]. Because clustering effects may exist for study subjects from the same residential area in this study, we used a robust error estimator to correct standard errors allowing for potential correlations [23]. Due to the small sample size, we calculated bootstrap-t confidence intervals [CI] at 95% based on 1,000 replications by assigning an equal probability to each study subject to be re-sampled with replacement [24].

We used a base multivariable model to examine the association between ever/near fallen outside and footpath quality, adjusted for age, gender, ethnicity, and previous fall history. Each additional variable of interest (i.e., remaining personal and situational characteristics) was added into the base model one a time. We used Quasi likelihood under the Independence model Criterion (QIC) to compare nested models (e.g., to compare base model and base model plus one additional variable of interest), and retained the variable for a model with smaller QIC.

Results

Discussion groups

Outdoor falls were mentioned in each of the discussion groups, either spontaneously or as a result of prompting by one of the researchers. The main themes that emerged in relation to outdoor falls in the discussions are summarized in Table 2.

In the four English groups, participants identified lack of lighting, uneven road and path surfaces, tree roots, and fallen seed pods from Plane trees (The London Plane tree (Platanus × Hybrida) is a common tree in the City of Sydney, and produces ball shaped seed pods approximately 2-3cm in diameter)., as common causes of falls. Environmental hazards were not identified as a cause of falls at the Chinese discussion groups where participants indicated that individuals are responsible for preventing falls, for example by *"walking carefully"*.

Survey

Falls and near falls

Of the 124 participants, 54.8% reported at least one fall or near-fall in the last two years. Forty percent reported actual falls, whereas 55% reported experiencing near falls only. Amongst the 68 participants asked to report the location of their most recent fall or near fall, 36.8% reported inside their own home or building, 7.4% inside other home or building, 25.0% outside near the home or building and 30.9% on the street.

Among those whose most recent fall/near fall occurred outdoors, 78.9% reported that they were walking at the time of the fall.

Outdoor fallers/near fallers

Forty-four participants were classified as having fallen or near fallen outdoors in the last 2 years, and 67 as not (56 people reported no falls or near falls and 11 people reported having fallen or nearly fallen only indoors) Thirteen participants could not be classified and were excluded from further analysis. Of the 44 outdoor fallers/near fallers, 45.5% were born in Australia, 22.7% were born in China, 9.1% were born in both the United Kingdom and New Zealand, and 13.6% were born elsewhere. The mean age of outdoor fallers/near fallers was 72.36 (range 61-86, median 72).

Regression analysis

Table 3 shows that an elevated risk of an outdoor fall or near fall was associated with lower footpath quality, as well as having a non-Asian ethnic background. None of the other variables of interest showed statistically significant effects.

Discussion

This study provided qualitative as well as quantitative evidence that outdoor falls are a substantial problem among community-dwelling older people living in the City of Sydney, affecting a large proportion of this population and occurring at least as often as indoor falls.

Table 2. Quotes from group discussions on emergent themes for outdoor falls

	Quotes from English-speaking focus group
Lighting	"When you have a walk through the area…if any of those lights fuse they have to attend to it" "We've got trees that are cutting out the light if you come down here at night you can't see where you're going" "Certainly better street lighting would help, because it's hard to see your way at night"
Uneven road and path surfaces	"Regarding management of aged, I would like to see the council making better pavements, pathways for seniors to walk on and less potholes along the road" "You just hit a bit of the pavement and then you're pitched off balance" "The pavement's come up and I keep tripping over [the bricks]" "[I fell over] the bricks sticking up from the pavement" "None of us can walk around at night because it's too dangerous with the bricks sticking up and the balls [Plane tree seed pods] from the trees" "When you're not falling over the bricks your falling over balls [Plane tree seed pods]"
Tree roots	"I personally experienced falling over a tree stump…as a result I go smash on the pavement" "The tree roots are a big problem" "I'm always falling over the roots" "The council had a tree…it's been there 8 or 9 years and now the asphalt is all coming up" "I use one of the pathways and you've got to look every step you take because the bricks are up from the tree trunks and tree stumps"
Fallen seed pods from Plane trees	"It drops these little seeds and they're dangerous for me because they're like little marbles" "Just one thing…how many times I fall in Baptist St, those trees if they could take them out…that's the worst thing about Australia (Plane tree seed pods)" "They've got the trees with the balls [Plane tree seed pods] on them, and the balls fall, and its like your on roller-skates"

	Quotes from Chinese-speaking focus group
Lack of concern	Interviewer: "What about the streets and crossings? Have you seen anything not good, such as a bumpy road?" Participants: "No." Interviewer: Has anyone been injured because of a bumpy road or a crack as mentioned…? Participants: "No." Participant: "You should walk carefully."

Falls were discussed at all of the focus groups with many participants recounting incidents of outdoor falls (spontaneously at three of the six focus groups). This was consistent with the survey findings that over one-third of the entire sample (or 64.7% of all fallers/near fallers) reported an outdoor fall or near fall. Hill et al. [12] also reported that over half of falls among healthy older women in Australia occur outdoors.

This study also identified a relationship between outdoor hazards and outdoor falls among community-dwelling older people. Participants in the English focus groups identified lighting, uneven road and path surfaces, fallen seed pods from Plane trees, and tree roots as hazards that contribute to falls. The hazards presented by trees have not been previously documented and are noteworthy because trees are a ubiquitous feature of Australian cities.

Table 3. Relative Risk (RR) and 95% Confidence Interval (CI) for outside falls/near falls in the multivariate regression model*

Variables	Category	RR (95%CI)
Footpath quality**		0.95(0.91,0.98)
Age group	<=64	0.41(0.18,0.81)
	65-69	0.94(0.57,1.67)
	70-74	1.25(0.82,2.26)
	75-79	0.66(0.32,1.23)
	80 and above	referent
Gender	female	1.04(0.75,1.52)
	male	referent
Ethnicity	non-Asian	1.70(1.15,2.59)
	Asian	referent
Previous fall history	no	1.11(0.76,1.74)
	yes	referent

*Fit statistics QIC (Quasi likelihood under the Independence model Criterion) for multivariate regression: QIC 251.49. The addition of other individual variable of interest did not improve the model fit
** Footpath quality was treated as continuous with a range of 18-45 see Supplemental document

Survey results indicated a relationship between perceived footpath quality (assessed in terms of 9 indicators) and experience of outdoor falls/near falls with variance due to other predicators accounted for in regression analyses.

These findings extend previous studies that identify particular outdoor locations as common locations of falls. Hill et al. [12] identified streets, parks, steps, curbs and public transport as frequent locations of falls among healthy older Australian women. Li et al. [14] reported sidewalks, streets and curbs as frequent locations of outdoor falls in Northern California, and asked participants who had experienced an outdoor fall whether they thought it was due to an uneven surface, a wet surface, tripping on an object, or slipping on an object. The present study also addressed particular hazards (aspects of footpath quality), but directly examined the relationship between perceived footpath quality and outdoor falls, rather than asking participants if they felt there was a relationship. The present Australian findings arrive at the same conclusion and suggest there is a relationship between falls and outdoor hazards similar to those investigated in the American study.

The finding that survey respondents with an Asian background were less likely to have experienced an outdoor fall than respondents with a non-Asian background is consistent with previous findings regarding hip fractures in Americans with an Asian versus a non-Asian background [20]. The present study did not demonstrate relationships of outdoor falls with other personal and situational characteristics that have previously demonstrated relationships with falls (typically measured without reference to location) [6,20]. This is most likely to be related to relatively small size of the present survey sample.

The present study has several limitations. Discussion groups were recruited from community centres, and so may have lower socioeconomic conditions than the average population. These groups' primary aim was preliminary exploration on issues relevant to the survey population, in order to adapt the survey instruments. A more representative sample was sought for the survey by utilising a range of recruitment strategies. Survey participants reported a wider range of incomes with an average similar to population estimates for this age group: between $19,916 for singles and $38,900 for couples [24]. The use of self-reporting raises concerns regarding accuracy of recall and reporting, and older people may underestimate fall incidence [25]. Hale et al. [25] found that the positive predictive value of recalling a fall in the past year was 92%, and that recall of falls in the past 12 months was more accurate than recall for 3 and 6 months. We restricted reporting of falls to the last two years, and our analysis relied on participants reporting a single fall or near fall, rather than the specific number of falls. Reporting bias was limited by assurances of confidentiality and anonymity. Finally, as with all cross-sectional studies, the present study is limited in the extent to which cause-effect relationships can be identified. For example, although we found that participants' perception of footpath quality was associated with an increased risk of an outdoor fall, we cannot discount the possibility that outdoor fallers/near fallers believed that footpath quality was poor due to their fall experience. Nonetheless, it is plausible that outdoor hazards may contribute to outdoor falls.

It might be worthwhile to reproduce this study with a younger, more able-bodied, less frail sample of the population to see if the perceptions of footpath quality and accompanying experience of trips and falls differ significantly. Although there are clear geographical features unique to Sydney, we think that these findings could be applied to many other cities. The added value of the present study is it is not restricted to the attribution of outdoor falls to environmental hazards. Instead, it gives a more detailed description of aspects that people consider hazardous. A next step would be to have independent surveyors audit aspects of the environment.

This study also has practical implications for the direction of future fall prevention initiatives. As Australia's population ages [26], it will become increasingly important to minimise the burden and costs associated with falls [27,28], and outdoor falls represent a substantial component of this public health burden. Thus, interventions that target outdoor falls may be worthwhile. Outdoor falls might be reduced by modifying the outdoor environment, in particular footpath quality and maintenance, and by raising awareness among community-dwelling older persons about the high incidence of outdoor falls, and about the possible influence of outdoor hazards on outdoor

falls. It is generally accepted that a multi-factorial, interdisciplinary prevention approach is the most effective strategy to prevent falls and accompanying functional impairment in older people. Combining an exercise programme, vitamin D supplements and reducing psychoactive drugs, and vision optimisation have been found to be the most effective strategies [29-31]. Based on our findings, we think much can be gained by optimising the quality of public space (footpath maintenance, and reducing hazards) in addition to existing strategies. Several good practice guides have been written in the past 5 years [32,33].

Acknowledgements

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