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The role of the environment in falls among stroke survivors

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Abstract

Background—Stroke survivors' risk of falls may be particularly sensitive to the environment due to deficits such as visuospatial neglect or homonymous hemianopia. We sought to identify the prevalence of falls among stroke survivors and investigate the possible role of the environment in falling.

Materials and Methods—Data from the National Health and Aging Trends Study (NHATS), a nationally representative population of community-dwelling adults over 65, were used. We compared the prevalence of falling in the past month between stroke survivors and demographic and comorbidity matched controls using sequential Poisson regression models.

Results—The proportion of stroke survivors reporting a fall in the previous month was 18.8% compared to 10.8% among matched controls (PR: 1.74; 95% CI: 1.36–2.25). These differences were attenuated after adjusting for known confounders, mediators and aspects of the environment (PR: 1.17; 95% CI: 0.86–1.60). Indoor tripping hazards were associated with falls (PR: 1.24; 95% CI: 1.01–1.53). The association between stroke and falls was modified by neighborhood social disorder, such that in areas of low social disorder, falls in the previous month were more common in stroke survivors compared to non-stroke controls.

Conclusions—The difference in falls among stroke survivors and matched controls is largely explained by known risk factors and physical capacity. Indoor tripping hazards were associated with falls among stroke survivors and matched controls. Explanations of why the association

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Disclosures
None

between stroke and falls was protective in areas of high social disorder are unclear, but may warrant additional research.

Keywords

Stroke; epidemiology; outcome after stroke; stroke in elderly; falls

1. Introduction

Falls are the leading cause of injury among older adults (Centers for Disease Control and Prevention [CDC], 2006), and are becoming more common over time (Cigolle et al., 2015). Falls can lead to fractures of the hip, spine, arm, pelvis, or wrist (Feldman & Chaudhury, 2008), and can have psychological effects including decreased quality of life through fear of falling, self-imposed activity restrictions, social isolation and depression (Vellas, Wayne, Romero, Baumgartner, & Garry, 1997). Additionally, falls are associated with increased hospitalizations, home health care, and nursing home placement (Alexander, Rivara, & Wolf, 1992; Gill, Murphy, Gahbauer, & Allore, 2013).

Risk factors for falls have been well-described and include, age, comorbidities, prior history of falls, balance or coordination problems, depression, vision and hearing impairments and limitations in lower extremity function (Chan et al., 2007; Ganz, Bao, Shekelle, & Rubenstein, 2007; Graafmans et al., 1996; Muir, Berg, Chesworth, & Speechley, 2008; Tinetti, Speechley, & Ginter, 1988). Stroke survivors have consistently high fall rates, with the proportion falling ranging from as low as 23% within a 4-month period (Jørgensen, Engstad, & Jacobsen, 2002) to as high as 70% for a 1-year follow-up (Weerdesteyn, de Niet, van Duijnhoven, & Geurts, 2008), and fall incidence rates between 1.4–5.0 falls each person-year (Weerdesteyn et al., 2008), with the risk increasing with greater physical disability (Divani, Vazquez, Barrett, Asadollahi, & Luft, 2009).

Poor conditions both inside and outside of the home may increase the likelihood of falling (Simpson, Miller, & Eng, 2011), particularly among those with limitations in physical capacity (Feldman & Chaudhury, 2008; Letts et al., 2010). Uneven sidewalks and sidewalk obstacles contribute to the vast majority of outdoor falls among older adults (Li et al., 2006). Indoor falls have been shown to be related to tripping hazards, including loose carpets and poor lighting (American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons Panel on Falls Prevention, 2001). Given that a stroke can cause sudden and severe disability with unique patterns of deficits in multiple neuroanatomic pathways, the environment may uniquely impact the fall risk in stroke survivors. For example, uneven sidewalks and sidewalk obstacles may be particularly problematic in a stroke survivor with visuospatial neglect or a homonymous hemianopia. Prior studies of falls among stroke survivors have not explored these environmental risk factors in a nationally representative sample (Divani et al., 2009; Weerdesteyn et al., 2008).

Our objectives were to identify prevalence ratios of falls among stroke survivors compared to matched non-stroke controls using nationally representative data of the community-dwelling Medicare population and to investigate the role that the environment may play in

falling. We hypothesize that 1) stroke survivors fall more than matched controls and 2) that environments increase the likelihood of falling in stroke survivors compared to controls.

2. Material and Methods

Stroke survivors were identified in the National Health and Aging Trends Study (NHATS). NHATS is a nationally representative face-to-face survey of over 8,000 Medicare beneficiaries aged greater than or equal to 65 years. The study design and procedures for NHATS have been described elsewhere (Freedman et al., 2011). Briefly, a stratified random sample of community-dwelling adults, living in the coterminous United States, were interviewed in 2011. NHATS oversamples for African Americans and adults in older age groups. A total of 892 stroke survivors were identified (738 by self-report and 154 by proxy report) based on a positive response to: “Has a doctor ever told you that you had a stroke?”

2.1 Outcome

NHATS participants (or proxies) reported if they fell in the last month (“Have you fallen down in the past month?”). This question was prefaced by the following definition: “By falling down, we mean any fall, slip, or trip in which you lose your balance and land on the floor or ground at a lower level.” Additional questions about falls in the last 12 months and if they had recurrent falls in the last 12 months (multiple falls) were used to create an indicator of history of falls. The decision to use the fall in the last month versus fall in the last 12 months as our primary outcome was based on the assumption that a shorter time frame (one month) would be associated with less recall bias/measurement error than a 12 month time frame.

2.2 Physical and Social Environments

To analyze the association of the physical environment on falls, we investigated a series of summary scores representing physical disorder. NHATS collects interviewer reported measures of the area where participants reside, conditions of the home (indoor and outdoor), along with what may be considered tripping or fall hazards (clutter) (Appendix 1 in Online Supplement). If examined separately, these 16 variables would likely be underpowered to examine associations with falls, and in modifying fall risk. Due to the ordinal or binary nature of the 16 physical environment variables, we used an exploratory factor analysis (EFA) to reduce the dimensionality of the elements and explore the underlying relationship among these variables. Polychoric correlations were used instead of Pearson correlations because of the ordinal nature of the variables. The first three factors explained almost 92% of the common variance with eigenvalues of 6.88, 5.16, and 2.63. Prior work has suggested that EFA/principal component analyses (PCA) can be used for complex survey designs, and while the true loadings and components may introduce bias due to the sampling strategy, we only used the EFA/PCA for grouping purposes (Saavedra, Barrington, & Vinokurov, 2008). The EFA suggested four components representing surrounding area conditions: 1) neighborhood social disorder; 2) outdoor condition of the home; 3) indoor tripping hazards; and 4) indoor aesthetics. Neighborhood social disorder was summarized by averaging the 4 area condition variables dealing with litter, graffiti, vacant/deserted homes, or foreclosures (scored 1–4, none-a lot) (Cagney et al., 2009). Similarly, the 5 questions regarding the

outdoor condition of the home (scored yes/no) were summed, but left as a count (0–5). The indoor conditions of the home were separated into 2 scores. The 3 items dealing with potential tripping hazards and clutter were combined into a summed score, but since tripping hazards was a yes/no question and clutter questions ranged from 1–3 (none to very cluttered), tripping hazards yes/no was scored 3/1, respectively. The 4 remaining indoor conditions (yes/no) were summed as a count (0–4) representing indoor aesthetics. Since the prevalence of many of the environmental conditions was low, we also created separate indicators for each of the four negative physical environment conditions (neighborhood social disorder, outdoor condition of the home, indoor tripping hazards, and indoor aesthetics).

Neighborhood social cohesion was assessed using a valid and reliable 3-item measure of community trust and exchange (how well people know each other, how willing they are to help one another, and can be trusted in the community) (Cagney et al., 2009). Higher scores represented greater social cohesion.

2.3 Potential Confounders and Mediators

NHATS collected a number of sociodemographic characteristics and comorbidities that were used to match stroke survivors with non-stroke controls. These characteristics were: gender, marital status, age, race/ethnicity, place of residence, myocardial infarction, coronary artery disease, hypertension, diabetes mellitus, cancer, lung disease, dementia, smoking, osteoporosis, and arthritis.

Aside from the matching variables, NHATS collected detailed data on numerous other variables that may confound (or in some cases mediate) the association between stroke and falls. Self-reported history of balance or coordination problems, living alone, depression (Patient Health Questionnaire [PHQ-2]), and vision or hearing impairment. The physical capacity measures asked whether they could perform tasks independently and without the use of assistive devices in the last month. Tasks were paired into less and more challenging functions (Freedman et al., 2011). A summary self-reported physical capacity index was created, with 1 point for every easy task and 2 points for every more challenging task performed (scores 0–12). Use of either an indoor or outdoor mobility device was summarized as any use of a mobility device (cane or walker). Further, NHATS asked respondents how often they went outside in the past month, ranging from never to every day.

This study protocol was reviewed by the University of Michigan Medical Institutional Review Board and was deemed to be not regulated as it relied on a publicly available, de-identified dataset.

2.4 Statistical Methods

Matched covariates and unmatched covariates (confounders and mediators) were summarized by stroke/non-stroke control status to demonstrate successful matching and to determine model adjustment after applying survey weights. Risk factors for falls that were also associated with stroke status ($p < 0.10$) were considered for model adjustment. Since falls were a common outcome, survey-weighted Poisson regression models were used to calculate prevalence ratios and confidence intervals comparing the prevalence of falls

according to stroke status adjusting for confounders. We further explored if worse environments modified the association between stroke and falls.

We examined the relation between stroke and falls with sequential adjustment of individual and environmental factors. Effect modification of the stroke-fall association was then explored by three measures of the physical environment (indoor aesthetics, outdoor conditions, and tripping hazards) and by neighborhood social disorder by including an interaction term between stroke and the effect modifier in the models.

As a sensitivity analysis, we also repeated the analyses for falls in the past 12-months. And as a post-hoc secondary analysis, we explored each individual environmental factor in our final regression model. All statistical analyses were conducted using SAS version 9.3 (Cary, NC) and Stata 11 (College Station, TX).

3. Results

Stroke survivors were similar to non-stroke controls in terms of matching characteristics. For unmatched characteristics, stroke survivors reported more balance or coordination problems, were more likely to have a history of falls, have depression, use a mobility device, had lower self-reported physical capacity, and were less likely to go outside often (Table 1). The proportion of stroke survivors reporting a fall in the previous month was 18.8% compared to 10.8% among matched controls. Using survey weights, this translates to approximately 665,000 elderly American community-dwelling stroke survivors falling in the previous month. In addition, in the past year, over 930,000 stroke survivors fell more than once.

There were no differences in indoor aesthetics, both with individual components and as an index (Appendix 2 in Online Supplement). Indoor tripping hazards and outdoor home conditions were similar between stroke survivors and matched controls. Marginal differences were observed for aspects of the social environment.

In unadjusted models, falls in the previous month were more common among stroke survivors compared to matched controls (PR: 1.74; 95% CI: 1.36–2.25) (Table 2). The association was partially explained after adjustment for mediators balance or coordination problems and history of falls in the prior year (PR: 1.31; 95% CI: 1.01–1.70). Additional adjustment for living alone, depression, and vision and hearing impairments further attenuated the association between stroke and falls, but remained borderline statistically significant (PR: 1.29; 95% CI: 0.99–1.69). Self-reported physical capacity and use of mobility devices pushed the association outside the bounds of statistical significance. Including physical environment scores further attenuated the association between stroke and falls and the additional influences of neighborhood social disorder, neighborhood social cohesion and how often the participants went outside were minimal. However, presence of indoor tripping hazards increased the prevalence of falls for both stroke survivors and controls by 24% (PR: 1.24; 95% CI: 1.01–1.53) in the fully adjusted model.

Evidence of effect modification of the stroke-falls association was only observed by neighborhood social disorder (Figure 1). In areas of low social disorder, falls in the previous month are more common in stroke survivors compared to non-stroke controls, but not in

areas of high social disorder. This association remained after accounting for greater prevalence of falls among those going outside more often in areas of low social disorder. Similarly, among non-stroke controls, those in areas of low social disorder had lower prevalence of falls compared to those in areas of high social disorder in all models.

The primary effects were not altered by looking at different fall durations (1 month or 12 months). Individual environmental predictors of falls in the fully adjusted model included evidence of broken furniture or lamps and the absence of houses or storefronts (Appendix 3 in Online Supplement).

4. Discussion

In this national sample of community-dwelling stroke survivors, we found that almost 20% of stroke survivors fall each month. This corresponds to more than 650,000 community-dwelling Medicare-enrolled stroke survivors falling every month. Over 70% more stroke survivors reported falling in the past month compared to matched controls. This was largely due to increased problems with balance and coordination as well as a history of falls in the past year.

Prior work has shown that those without a history of falling, were more likely to fall in the presence of home hazards, while those with a history of falling had no increased risk of falls in the presence of home hazards (Van Bommel, Vandenbroucke, Westendorp, & Gussekloo, 2005). In our study, we observed a strong association between indoor tripping hazards and greater prevalence of falls, with the presence of tripping hazards increasing the prevalence of falling in the past month by about 25%. The association between indoor tripping hazards and falls did not differ among stroke survivors and matched controls, which may suggest that the outdoor environment may be a more important predictor of differences in the association between stroke and falls than the indoor environment.

This was the first study, to our knowledge, to examine how the social environment influences the prevalence of falls following stroke. While conditions outside the home and neighborhood social cohesion had little effect on falls, neighborhood social disorder was found to moderate the effect of stroke on falls. Contrary to our expectations, stroke survivors had a higher prevalence of falling in areas of lower neighborhood social disorder. This was also demonstrated by the finding that the association between high neighborhood social disorder was a stronger risk factor for falls among matched controls, and actually became borderline protective among stroke survivors.

This result was echoed when looking at the presence of vacant or deserted houses. It may be that stroke survivors are less likely to walk outside if they do not feel safe which may lead to fewer opportunities to fall. The perception or fear of falling and the anxiety associated with falling is a common response among the elderly who have fallen outdoors (Nyman, Ballinger, Phillips, & Newton, 2013). This fear may be compounded by elements of social disorder which may prevent the elderly from asking other pedestrians or neighbors for walking assistance (Chippendale & Boltz, 2015). Or in the case of vacant/deserted homes, the lack of neighbors may increase the fear that if they fell, there would not be assistance.

Therefore it is possible that stroke survivors, given their lower physical capacity, adapt to this fear by avoiding going outside in areas of greater disorder (less safety and less cohesion). Another possibility that should be mentioned is that the observed interaction between neighborhood social disorder and stroke on the prevalence of falls could be spurious, and requires further study.

Interventions have been shown to have some success in reducing falls (Albert, Edelstein, et al., 2014; Albert, King, et al., 2014; Lord, Menz, & Sherrington, 2006). A simple intervention that could have a large impact would be to have home helpers pick up tripping hazards at home, cleaning up clutter and walking paths. Assuming that the observed association was causal, if all sources of clutter and tripping hazards were improved, an estimated 200,000 less individuals would have fallen each month.

This study was not without limitations. This study was a cross-sectional survey, and as such we cannot determine the timing of stroke onset relative to falls and the measures of the environment. This temporal ambiguity limits our study to assess associations and is primarily hypothesis generating. Our measurement of exposures (stroke, environment scores) may suffer from some level of misclassification as they are self-reported and interviewer reported. Our study relies on self-reported stroke and we cannot be sure that all stroke survivors reported their strokes. However, data suggests high accuracy of self-reported stroke in the elderly (Engstad, Bonaa, & Viitanen, 2000; Horner, Cohen, & Blazer, 2001; Okura, Urban, Mahoney, Jacobsen, & Rodeheffer, 2004). Without information on the timing of stroke, specifically how long ago it occurred and the use of self-reported strokes, may bias our results toward the null. The incidence rates for falls among stroke survivors are higher after discharge from the hospital (Forster & Young, 1995). It is also unknown if the reported falls resulted in injury or were minor, which would bias the true association between stroke and falls, whether they occurred indoors or outdoors, which would allow for better understanding of the environmental exposures, or the frequency of falls for each individual, which would also help in understanding fall risk. The results of this study are limited to the community-dwelling Medicare population, and may not be generalizable to younger populations.

5. Conclusions

Almost one out of every five community-dwelling elderly stroke survivors fall every month. Indoor tripping hazards were a significant risk factor for falls in the community-dwelling population, however, the presence of these hazards did not largely influence the difference in fall prevalence between stroke survivors and matched controls. The stroke difference was largely explained by known risk factors and differences in physical capacity. The reasons behind why the association between stroke and falls was protective in areas of high social disorder are unclear, but warrant future exploration.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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None

List of abbreviations and acronyms

EFA	Exploratory factor analysis
NHATS	National Health and Aging Trends Study
PCA	Principal component analysis
PHQ-2	Patient Health Questionnaire

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Highlights

- Stroke survivors were more likely to fall in the past month than matched controls.
- Differences in fall prevalence were largely explained by known risk factors and physical capacity.
- Indoor tripping hazards were associated with a greater prevalence of falling across both groups.
- Explanations of the protective effect of social disorder warrant additional consideration.

Figure 1. Marginal proportion of falls in the previous month by neighborhood social disorder and stroke status for (A) unadjusted and (B) fully adjusted (balance/coordination problems, history of falls in past year, living alone, depression, vision impairment, hearing impairment, physical capacity score, use of mobility device, indoor aesthetics, outdoor conditions, tripping hazards, and going outside often) models in the National Health and Aging Trends Study 2011.

Table 1

Survey-weighted characteristics of stroke survivors and non-stroke matched controls in the National Health and Aging Trends Study 2011

Characteristic	Stroke N=892 %	Control N=892 %	p-value
Age			
65–69	17.7	17.9	0.98
70–74	21.5	22.0	
75–79	18.6	19.0	
80–84	21.0	19.1	
85–89	14.3	14.8	
90+	7.0	7.3	
Female	56.9	55.3	0.55
Race/ethnicity			
White	78.9	80.0	0.94
Black	10.1	10.2	
Hispanic	6.7	6.1	
Comorbidities *			
Myocardial infarction	31.0	30.6	0.86
Coronary Artery Disease	30.1	28.6	0.52
Hypertension	78.2	75.3	0.20
Diabetes mellitus	36.2	34.1	0.46
Cancer	27.9	25.1	0.13
Lung Disease	21.0	18.5	0.28
Dementia	11.8	9.5	0.17
Osteoporosis	27.8	24.5	0.20
Arthritis	64.3	63.8	0.86
Unmatched characteristics			
Married *	46.5	48.9	0.38
Education †	n=377	n=391	0.12
Less than HS	21.5	17.9	
HS graduate	57.0	54.3	
College graduate	21.5	27.8	
Balance/coordination problems *	52.4	34.6	<0.001
History of prior fall in last year	19.7	15.8	<0.001
Live alone *	16.7	16.3	0.75
Depression *	13.5	9.2	0.03
Vision impairment *	62.5	62.6	0.97

Characteristic	Stroke	Control	
	N=892 %	N=892 %	p-value
Hearing impairment	13.9	15.4	0.35
Physical capacity score (self-report), mean (SE) *	6.58 (0.12)	8.21 (0.98)	<0.001
Mobility device	22.8	15.1	<0.001
Going outside often *			<0.001
<i>Never</i>	2.2	2.5	
<i>Rarely (once a week or less)</i>	10.4	5.2	
<i>Some days (2–4 days a week)</i>	17.2	12.8	
<i>Most days (5–6 days a week)</i>	18.1	18.8	
<i>Every day (7 days a week)</i>	52.0	60.6	

* Missing < 1%

† Only available for subset of subjects

Prevalence ratios for falls in the previous month: stroke survivors and matched controls in the National Health and Aging Trends Study 2011

Table 2

Prevalence ratios	Model 1 PR (95% CI)	Model 2 PR (95% CI)	Model 3 PR (95% CI)	Model 4 PR (95% CI)	Model 5 PR (95% CI)	Model 6 PR (95% CI)
Stroke vs. non-stroke control	1.74 (1.36, 2.25)	1.31 (1.01, 1.70)	1.29 (0.99, 1.69)	1.23 (0.93, 1.62)	1.20 (0.88, 1.62)	1.17 (0.86, 1.60)
Balance or coordination problems		2.91 (2.01, 4.20)	2.83 (1.91, 4.18)	2.35 (1.60, 3.46)	2.35 (1.57, 3.52)	2.34 (1.55, 3.53)
History of prior fall in last year		3.05 (2.35, 3.96)	3.02 (2.30, 3.96)	2.83 (2.16, 3.72)	2.70 (2.06, 3.56)	2.67 (2.04, 3.50)
Living alone			0.92 (0.70, 1.20)	0.89 (0.68, 1.17)	0.81 (0.60, 1.10)	0.81 (0.60, 1.09)
Depression			1.21 (0.86, 1.71)	1.08 (0.78, 1.51)	1.13 (0.79, 1.61)	1.14 (0.80, 1.62)
Vision impairment			0.83 (0.62, 1.10)	0.82 (0.62, 1.08)	0.89 (0.66, 1.20)	0.89 (0.66, 1.20)
Hearing impairment			1.30 (0.95, 1.80)	1.32 (0.96, 1.92)	1.36 (0.96, 1.92)	1.34 (0.96, 1.89)
Physical Capacity Score (self-report)				0.95 (0.91, 1.00)	0.96 (0.92, 1.00)	0.95 (0.91, 1.00)
Use of mobility device				1.18 (0.87, 1.60)	1.16 (0.88, 1.54)	1.17 (0.88, 1.55)
Indoor aesthetics					1.11 (0.78, 1.58)	1.14 (0.77, 1.69)
Outdoor conditions					1.01 (0.71, 1.44)	1.04 (0.72, 1.50)
Tripping hazards					1.26 (1.03, 1.56)	1.24 (1.01, 1.53)
Neighborhood social disorder (higher worse)						0.82 (0.47, 1.41)
Neighborhood social cohesion (higher better)						0.94 (0.76, 1.18)
Go outside often (higher outside more)						1.04 (0.95, 1.14)