THE GERONTOLOGICAL SOCIETY OF AMERICA®

*Journals of Gerontology: Medical Sciences*
cite as: *J Gerontol A Biol Sci Med Sci*, 2020, Vol. 75, No. 5, 946–951
doi:10.1093/gerona/glz114
Advance Access publication May 4, 2019

OXFORD

Research Article

# The Five W's of Falls: Weekly Online Health Survey of Community-Dwelling Older Adults: Analysis of 4 Years Prospective Follow-up

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Received: November 5, 2018; Editorial Decision Date: April 24, 2019

**Decision Editor:** Anne Newman, MD, MPH

## Abstract

**Background:** An in-depth examination of prospectively collected falls details may facilitate more effective falls prevention. Who was involved? What happened? Where did the fall take place? When did it happen? Why did it occur? This study aimed to provide previously unavailable details about the circumstances surrounding fall events and their consequences.
**Method:** A retrospective analysis of falls prospectively self-reported by older adults via an online weekly health form over 4 years.
**Results:** We collected 371 falls during the 4 year time period from 120 clinically characterized fallers (74% women, mean age 83.3 years). Most of the 371 falls occurred indoors (62%) and in well-lit areas (81%). Bedrooms were the most common places for in-home falls. Commonly observed precipitating factors included loss of balance, slipping or tripping. Almost one-third (31%) of falls were defined as injurious whereas 22% resulted in a change in the walking ability of which 26% led to the use of a cane or walker. Among falls that did not give rise to any formal health care intervention, 8% resulted in a modification of walking ability.
**Conclusions:** A relatively high rate of fall-related injuries compared to the existing literature was observed. Online weekly surveys and the richness of details provided through these data capture method allowed us to identify falls that did not result in health care utilization but did result in decreased mobility. This finding suggests why some falls classified in the literature as noninjurious may nevertheless increase the risk of loss of autonomy and undesired outcomes.

**Keywords:** Falls, Information and communication technologies, Online survey, Internet.

Despite their impact on older individual's lives and decades of intensive research, falls remain a challenging issue for health professionals (1,2). One concern in falls management is the lack of data on the detailed circumstances of falls and related injuries. Another challenge is the inconsistency of fall injury classifications (3,4). Drawing a distinction between noninjurious and injurious falls has been problematic. Difficulties include that the definitions are limited by the richness, or lack thereof, of the available data source and collection methods (4,5). The "Five W's" is a time-honored mnemonic that helps clinicians and researchers to address fundamental questions leading to a comprehensive overview of an event: Who was involved? What happened? Where did the fall take place? When did the fall occur? Why did the fall occur? Obtaining this information within the course of everyday life of older adults is difficult; falls are episodic and unpredictable and thus are particularly challenging to recall and describe.

Previous research examining falls have used hospital records, registers that included both fall-related hospitalizations and outpatient care, and self-reports (6,7). Health care records and registers are limited in their quality and comprehensiveness, especially in the community setting (3). They likely underestimate the true number of falls experienced by older adults and, in particular, the number of falls not classified as injurious (4,5) despite the fact that these have been shown to increase the risk of autonomy loss (1). Self-report

cross-sectional surveys may include larger samples and report falls that did not lead to medical care. However, they are susceptible to inaccuracy and recall bias (4) as participants are generally asked to report on falls during the previous 12 months (8,9). Prospective studies, on their part, rarely have follow-up timing longer than 12 months (10–12) and the recording of falls is generally based on a monthly recall (10,11), which could also alter the reliability.

Previous literature has often failed to provide detailed information about falls occurring in the community setting and potential daily life consequences of those falls beyond health care utilization (5,13,14). Thus, such information could facilitate more effective approaches to fall prevention. To address this gap, we used a weekly prospective online survey to collect self-reported falls from community-dwelling older adults over a 4 year period. We hypothesized that we could collect previously unavailable detail on the circumstances surrounding the falls. The specific aims of this long-term ongoing survey were to (i) compare subject characteristics according to whether the fall resulted in injury (Who?); (ii) describe the consequences of falls (What?); and (iii) describe the circumstances of the falls in terms of time and location, precipitating factors according to their injurious nature (Where? When? Why?).

## Methods

### Study Design and Participants

This study used data from two longitudinal cohort studies of aging developed by the Oregon Center for Aging and Technology (ORCATECH): the ORCATECH Life Laboratory study and the ISAAC (Intelligent Systems for Assessing Aging Change) study. The ORCATECH Life Laboratory study cohort was a precursor study to ISAAC study. The study protocols were identical and were approved by the Oregon Health and Science University Review Board (Life Laboratory IRB# 2765; ISAAC IRB# 2353). Full details of study protocol have previously been described (15).

Participants were already enrolled in one of the two studies. Inclusion criteria were being men or women 60 years or older for the Life Laboratory study and 80 years or older for the ISAAC study, living independently without a formal caregiver, not demented with a Clinical Dementia Rating Score of less than or equal to 0.5 (16) and Mini-Mental State Examination score of more than 24 (17), and being of average health for age with relatively stable common chronic health conditions. Exclusion criteria were health conditions that may limit physical participation (eg, wheel-chair bound) or led to death within 3 years (eg, late-stage cancer).

Participants respond to weekly scheduled health questionnaire. They received the form via e-mail each week. The questionnaire includes questions about health within the past week including falls. Participants are required to provide additional details if they respond "yes" (see Supplementary Appendix 1: Subject Fall Report Form). If a participant reported a fall, a research assistant would follow-up by phone call each day to collect the additional standardized information regarding circumstances, treatment, and consequences. Participants who did not fill out a form for 2 consecutive weeks were also contacted. Data from the online questionnaires are time stamped and are stored in a Structured Query Language database. For this study, we included all participants who were enrolled during the 4 year time period from June 2014 to June 2018 and who were completing the online weekly health forms. In a previous publication (18), we showed that of all participants, online weekly health forms were submitted on schedule 75% of the time.

### Clinical Assessment Procedures

Standard clinical and cognitive measures were administered on a yearly basis. Motor tests included: Tinetti Gait and Balance Instrument (19); grip strength and stopwatch-measured walking speed at their average pace (20). Health status was assessed via the modified Cumulative Illness Rating Scale (21). The Mini-Mental State Examination (17) was administered as well as the Geriatric Depression Scale (22).

A fall was defined as "an unexpected event in which the person comes to rest on the ground, floor, or lower level" (4). We reviewed all fall-related injuries, including minor ones (eg, bruises), reported by the participants (8,9). We defined an injurious fall as a fall resulting in any injury leading to professional health care (7,23–25) and/or with consequences on walking ability in the following days (5,13,14). We excluded falls leading to outpatient care resulting in no treatment and without consequences on walking ability from the injurious falls definition.

### Statistical Analysis

We compared baseline demographics, clinical and cognitive measures among older adults who reported at least one fall to those who did not report a fall and those who reported at least one injurious fall versus those who reported fall(s) not classified as injurious. These data were obtained from the most recent clinical evaluation within one year preceding the start of the analysis. We compared location, time, and precipitating factors among injurious versus noninjurious falls. A Chi-square test or Fisher's Exact Test (for small cell sizes) was used to examine cross-sectional group differences in categorical variables. For each continuous variable, the histogram was visually inspected and a goodness-of-fit test was used to determine the normality of the sample distribution. A two-sample *t*-test or Wilcoxon rank-sum test (its nonparametric counterpart) was used to examine group differences in continuous variables. Analyses were performed using SAS software, version 9.4 (Cary, NC).

## Results

During the June 2014 to June 2018 four year time period, 158 participants were enrolled and completed the online weekly health forms. Three hundred seventy-one falls were self-reported by 120 participants during the same period. The mean number of falls reported per person was 2.9 (*SD* ± 2.4, range: 1–16). The observed incidence rate of falls was 120 falls for 254.8 person-years or a 47% incident falls rate per year.

### Characteristics of Fallers: The Who?

Table 1 describes the older adults who reported a fall during the 4 years period ($n$ = 120) and those who did not ($n$ = 38). There were no differences in participant characteristics between groups.

Table 2 describes the 120 older adults who experienced no injurious falls ($n$ = 49) versus those with one or more injurious falls ($n$ = 71). The mean follow-up time during the period of interest (June 2014 to June 2018) was 3.2 years (*SD* ± 1.0). There were no differences in participant characteristics between groups.

### Fall Consequences: The What?

Fall consequences, treatments, and care following the falls are described in Supplementary Table 3. Among falls leading to an injury and to a health professional intervention ($n$ = 119), 19% ($n$ = 23)

**Table 1.** Participant Characteristics of Fallers and Nonfallers ($n$ = 158)

| | Nonfallers ($n$ = 38) | Fallers ($n$ = 120) | |
|---|---|---|---|
| Participant characteristics | Mean (*SD*) or % | Mean (*SD*) or % | $p$ Value |
| Age (yrs) | 82.8 (8.9) | 83.3 (8.0) | .75 |
| Gender (% women) | 82% | 74% | .35 |
| Education (yrs) | 15.3 (2.7) | 15.6 (2.7) | .57 |
| Non-white (%) | 5% | 14% | .25 |
| BMI (kg/m$^2$) | 27.1 (6.3) | 28.3 (5.9) | .31 |
| CIRS | 20.2 (2.8) | 20.8 (2.3) | .15 |
| MMSE | 27.9 (2.4) | 28.6 (1.5) | .19 |

*Note*: BMI = body mass index; CIRS = Cumulative Illness Rating Scale; MMSE = Mini-Mental State Examination.

**Table 2.** Participant Characteristics According to the Injurious Nature of the Fall ($n$ = 120)

| | No injurious fall ($n$ = 49) | Injurious fall(s) ($n$ = 71) | |
|---|---|---|---|
| Participant characteristics | Mean (*SD*) or % | Mean (*SD*) or % | $p$ Value |
| Age (yrs) | 83.4 (6.3) | 83.2 (9.0) | .80 |
| Gender (% women) | 76% | 73% | .78 |
| Education (yrs) | 15.7 (2.7) | 15.6 (2.7) | .43 |
| Non-white (%) | 20% | 10% | .10 |
| BMI (kg/m$^2$) | 28.8 (6.8) | 27.9 (5.1) | .78 |
| CIRS | 20.8 (2.3) | 20.9 (2.3) | .74 |
| MMSE | 28.4 (1.5) | 28.8 (1.5) | .06 |
| GDS | 0.9 (1.5) | 1.5 (2.3) | .17 |
| Clinical motor measures | | | |
| Tinetti gait | 1.8 (2.4) | 2.6 (2.6) | .10 |
| Tinetti balance | 4.5 (4.8) | 5.4 (5.0) | .32 |
| Walking speed (m/s) | 0.7 (0.2) | 0.7 (0.2) | .57 |
| Grip strength (dynes) | 19.0 (7.8) | 18.4 (8.7) | .98 |

*Note*: BMI = body mass index; CIRS = Cumulative Illness Rating Scale; MMSE = Mini-Mental State Examination; GDS, Geriatric Depression Scale. CIRS measures level of impairment (0–4) in 14 body or organ systems, higher scores are worse; MMSE ranges from 0 to 30, higher score indicates better cognition; GDS ranges from 0 to 15, higher score is worse (more depressive symptoms); Tinetti Gait and Balance scores measure gait abnormalities related to functional status and falls, higher score is worse; walking speed is correlated with the risk of functional autonomy loss and falls, lower gait speed is worse.

received no subsequent treatment at all and presented no consequences on walking (and consequently were not considered as injurious falls). Five falls resulted in a head injury including two concussions, two cerebral hemorrhages, and one subdural hematoma. At the time of the fall, 13 participants indicated that they successfully used their alert button whereas eight indicated that they were not able to use it or had to scoot themselves to get it as they were not wearing it. More than half of all falls did not give rise to any health care professional visit. Of these, 8% ($n$ = 19) resulted in a modification of walking ability.

### Fall Circumstances: The Where? When? And Why?

Location, time, and precipitating factors according to the injurious nature of falls are described in Supplementary Table 4. More than one-third of falls occurred outdoors. Among outdoor falls, 5% ($n$ = 7) occurred on public transportation or buses. Of falls that occurred in their home, the bedroom and living room were most common locations. Nineteen percent of all falls occurred in "poor" (dark or low) lighting. Twenty-one percent of falls occurred in the late evening or night. Stairways were not a frequent location for a fall to occur with only 2% ($n$ = 7) of falls reported on stairs. Except for 3% of falls that occurred in unusual situations (eg, climbing out of a dragon boat) most occurred during every day basic living activities. Almost all participants (90%) reported losing their balance as a precipitating factor and nearly two-thirds (64%) reported a slip or trip as a precipitating factor. According to participants, eight falls involved a pet dog (mostly by pulling on leash). For 206 falls an "other" precipitating factor was involved, from "ankle or knee gave out" to "in an angry mood".

When comparing falls according to their injurious nature, we observed no significant differences except for precipitating factors: lost balance was more likely to be involved and light-headed or faint and "uncertain" precipitating factor were, respectively, 2.7- and 2.6-fold times more likely to be reported during an injurious fall. We observed no differences in the prevalence of injurious falls among all falls by season ($p$ = .95).

## Discussion

### Main Results

The most notable finding of our study is the relatively high rate of falls-related injury and the number of falls followed by mobility problems, but not leading to medical attention. We reported 30% of falls considered as "injurious" and 70% resulting in any kind of injury, compared to the 20%–66% injury range cited in the literature (2,8,24,26). Similarly, our fracture rate (6%) is in the upper range

(2,8). This difference is likely due to our high-frequency data collection method rather than the definitions adopted. Some authors define injurious falls as any fall requiring hospitalization or outpatient care (7,23–25). Others include minor injuries such as bruises and abrasions (8), or rely on the participants' judgment (eg, "have you been injured?") (9). In comparison, our injurious definition—not including all types of injuries and excluding certain falls leading to outpatient care—could even be considered relatively restrictive. The inclusion of mobility limitations did not explain the reported rates; applying a more "traditional" definition (ie, all falls requiring medical attention), we found a 32% rate of falls compared to the 20% rate usually reported with such definitions (2,24,26). Moreover, we suggest that our definition could potentially fit those consistent with serious fall injuries. Beyond the inclusion of fractures, definitions vary from narrow (2,13,14) to broad including all falls resulting in an injury that led to hospital admission (5,6), or even to all falls requiring medical attention (27–29), and thus there is overlap across injurious falls definitions. Studies using more restrictive definitions report prevalence rates closer to 5%–15% (2,5,14,30). A study in a comparable population (women living at home, age: 81 years), using a broad definition of serious injuries (ie, resulting in medical care) (28) found a 24% prevalence rate. Speechley and Tinetti (31) also found that vigorous older adults were more prone to fall-related serious injuries and reported a similar rate.

The prevalence of falls not resulting in health care, but with subsequently decreased activity or mobility, a very important issue in geriatric care, is another notable result of our study. A high proportion of participants reported a change in the way they walked following the fall (of which one-quarter resulted in the use of a cane or a walker). Furthermore, among the falls with no health care follow-up, 8% resulted in a modification of walking ability. This previously unattainable detail was made available because of the short recall interval and the methods of documentation. This observation suggests that signs are underreported after a fall (32). Their inclusion in our injurious fall definition is in line with other publications that point out the importance of considering this outcome as serious falls injuries (13,14) or at least as "clinically important" falls (5).

For the fall circumstances, our results are congruent with the literature reporting 50%–60% of falls occurring within the home, mostly in commonly used rooms (8). This could be explained by the fact that this population spends on average 20.5 hours a day in their homes (15). Most reported falls occurred during morning and afternoon to early evening in our study. We did not find comparable data in community setting, but it is comparable to that observed in nursing homes (33). Concerning precipitating factors, our findings are also concordant with other studies. Balance impairment is one of the strongest risk factors for falling (1,28); slips and trips are a common cause of falls (8,29), as well as uneven floors and negotiating steps or stairs (8). Our results confirm the importance of environmental evaluation for fall prevention and may serve as a benchmark for falls experience in relatively healthy, educated older populations.

We did not observe significant differences in participant's characteristics (injurious vs. noninjurious fall group). Poorer balance and cognition are known to be independently associated with experiencing an injurious fall (34). Nevertheless, Welmer and colleagues (7) found that balance and walking speed were significantly associated with increased risk of injurious falls only in adults with cognitive impairment, who are potentially underrepresented in our sample (we do not know the number of patients with mild cognitive impairment). We observed a higher report of being light-headed or faint and "uncertain" as precipitating factors before an injurious fall. This could be explained by associated loss of consciousness, but there was little evidence to support such hypothesis. Determinants of injurious falls are poorly understood (2); this warrants additional analysis and follow-up, using complementary collection methods.

## Limitations

We excluded falls leading to outpatient care but resulting in no treatment and without consequences on walking ability from our injurious falls definition (eg, a person referred for a knee pain and sent home after a normal X-ray). We assume that, from a health care utilization standpoint, this kind of situation might be a threshold for "serious" but noninjurious fall and that it could also exclude patients presenting a high risk of subsequent functional decline such as an isolated fear of falling (35). If falls usually classified as not injurious can have negative health impacts (1,13,14), it is not yet clear to what extent this could be a direct physical consequence of the fall. The most serious limitation of our definition is the absence of differentiation between "short" and "long"-term mobility problems. Although other authors proposed a specific duration: "at least three days" (13,14) or "one week" (5), we describe a subjective duration of "several days". We were not able to differentiate, for example, transient limping from a definitive walking limitation and its consequences.

If injuries such as fractures are likely to be accurately reported, other ones may be poorly documented in medical records (4,5). Our collection method potentially limited such shortcoming. Calendar, diary, and postcard reportings have mainly been used in prospective trials generally with a backup retrospective telephone recall (6,11) and are exposed to recall bias. A systematic literature review of prospective studies monitoring falls concluded that researchers should gather information every week from participants to seek good accuracy (12). However, circumstances surrounding the falls and description of precipitating factors were not as accurate as expected. This study relied on subjective interpretation and reported precipitating factors should be interpreted cautiously (36). The use of more objective measures such as video capture (33), sensor-based activity (36,37), or a combination of collection strategies (28,29) would be useful to obtain a more comprehensive understanding of falls experience.

Finally, our computer-based collection method likely influenced the sample selection. Our octogenarian sample is well educated with high cognitive capabilities. They adhere to completing computer-based forms, requiring the ability to launch programs from their desktop and receive e-mail. Given the strong relationship between cognitive function and falls (6,7), this may limit the ability to generalize our findings. Nevertheless, most reported data would fit with persons with functional and/or cognitive impairment: relatively high fracture rate, indoor location, occurring during everyday basic living activities. Thus, any difference in reported rates may be related to the collection method rather than a biased recruitment. Finally, these "early adopters" of technology may be representative of the older adult population in the next decade (36).

## Consequences for Clinical Care and Conclusion

Screening and addressing these "silent and injurious falls" not resulting in health care but with decreased mobility could represent an important axis of care improvement for fall prevention programs. These underreported consequences may partly explain that previous literature has shown falls usually classified as noninjurious can increase the risk of skilled nursing facility placement by threefold (1)

and some authors argue for their inclusion in the serious injuries classification (5,13,14). It is important to assess for any kind of mobility limitation after a fall, irrespective of apparent injury and to take necessary prevention measures (5,35,38). Cognitively healthy older adults are a relevant prevention target, as the effectiveness of fall prevention in cognitively impaired older adults remains unknown (1). In addition, in this study, eight participants indicated that they were not able to successfully use their alert button on their call device. This point highlights the need for improved design of alert systems. In conclusion, using a weekly online data collection method, we were able to apply an original definition of injurious falls tailored to a geriatric population. We found a high rate of injurious falls potentially revealing a declaration bias in this population and the underestimation of "silent and injurious falls" not resulting in health care. Our findings emphasize the need to address untreated post-fall disturbances in older adults.

## Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

## Acknowledgment

Authors' specific areas of contributions: study concept and design: J.K., N.M., N.S., T.R.; acquisition of data: T.R., C.D., N.M., N.S., A.P.; analysis and interpretation of data: A.P., N.M.; drafting of the manuscript: A.P., N.M.; critical revision of the manuscript for important intellectual content: J.K.

## Funding

This work was supported by the National Institutes of Health (grants numbers R01AG024059, U2CAG054397, P30AG024978, and P30AG008017).

## Conflict of Interest

The authors have no conflict of interest to declare.

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