THE GERONTOLOGICAL SOCIETY OF AMERICA®

Journals of Gerontology: Medical Sciences
cite as: *J Gerontol A Biol Sci Med Sci*, 2018, Vol. 73, No. 2, 233–239
doi:10.1093/gerona/glx115
Advance Access publication June 9, 2017

OXFORD

Research Article

Risk Profiles for Injurious Falls in People Over 60: A Population-Based Cohort Study

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Received: October 7, 2016; Editorial Decision Date: May 31, 2017

Decision Editor: Stephen Kritchevsky, PhD

Abstract

Background: Although falls in older adults are related to multiple risk factors, these factors have commonly been studied individually. We aimed to identify risk profiles for injurious falls in older adults by detecting clusters of established risk factors and quantifying their impact on fall risk.

Methods: Participants were 2,566 people, aged 60 years and older, from the population-based Swedish National Study on Aging and Care in Kungsholmen. Injurious falls was defined as hospitalization for or receipt of outpatient care because a fall. Cluster analysis was used to identify aggregation of possible risk factors including chronic diseases, fall-risk increasing drugs (FRIDs), physical and cognitive impairments, and lifestyle-related factors. Associations between the clusters and injurious falls over 3, 5, and 10 years were estimated using flexible parametric survival models.

Results: Five clusters were identified including: a "healthy", a "well-functioning with multimorbidity", a "well-functioning, with multimorbidity and high FRID consumption", a "physically and cognitively impaired", and a "disabled" cluster. The risk of injurious falls for all groups was significantly higher than for the first cluster of healthy individuals in the reference category. Hazard ratios (95% confidence intervals) ranged from 1.71 (1.02–2.66) for the second cluster to 12.67 (7.38–21.75) for the last cluster over 3 years of follow-up. The highest risk was observed in the last two clusters with high burden of physical and cognitive impairments.

Conclusion: Risk factors for injurious fall tend to aggregate, representing different levels of risk for falls. Our findings can be useful to tailor and prioritize clinical and public health interventions.

Keywords: Fall risk factor, Cluster analysis, Swedish National study on Aging and Care in Kungsholmen (SNAC-K), Injury, Community-dwelling

Falls are a major public health concern, posing tremendous burdens on older people, their families, and the society. One out of three persons over the age of 60 experiences a fall each year (1,2), and 10% of those result in an injurious outcome that need medical care (1). Injurious falls are associated with increased risk of hospitalization, functional dependence, reduced quality of life, and premature death (2).

In recent decades, an increasing number of epidemiological studies have investigated risk factors for falls (1–4). Several risk factors have been identified including: sociodemographic (eg, age, sex, living situation, physical inactivity), psychologic and medical (eg, cognitive impairment, depressive symptoms, chronic diseases, pain), medication use (eg, fall-risk increasing drugs), and mobility and sensory factors (eg, balance and gait impairments, vision problems) (4–6).

Despite extensive research on individual risk factors in older people the possibilities to predict who will fall and who will not is still quite low (7), possibly because risk factors interact rather than having an independent effect. To our knowledge, only two studies have studied specific patterns of fall risk factors in relation to falls (8,9). These studies have showed that combining risk factors result in the best prediction of future fall risk. However, none of these studies have examined clusters of risk factors in relation to injurious falls over different lengths of follow-up. Knowledge of the relationship between these risk factors may help clinicians to tailor interventions by identifying people at different risk levels for injurious falls.

The aim of this study was to detect different risk groups of older adults based on previously identified sociodemographic, psychologic, medical, medication use, mobility, and sensory risk factors for falls. Furthermore, we aimed to examine to what extent the risk of injurious falls differs between those groups, over a short, medium, and long follow-up time (3, 5, and 10 years, respectively). Finally, we explored to what extent the different risk-combinations in the specific clusters was attributable to injurious falls.

Methods

Study Population

We used data from the Swedish National study on Aging and Care in Kungsholmen (SNAC-K) (10). The population in Kungsholmen, a central area of Stockholm, were first stratified by age and then randomly sampled from each of the 11 age cohorts (60, 66, 72, 78, 81, 84, 87, 90, 93, 96, and 99+ years). At baseline survey (year 2001–2004), 5,111 persons were initially invited to participate in the SNAC-K study, of those 200 died before start of the study, 262 were not able to be contacted, 4 were deaf, 23 did not speak Swedish, and 32 had moved out. Of the remaining 4,590 persons, 3,363 (73.3%) were examined at baseline. We excluded participants with missing data on any of the variables included in the cluster analysis (n = 797). The analytical sample (n = 2,566) was significantly younger (baseline mean age ± SD 72.1 ± 9.86 vs 83.3 ± 10.95, p < .001), included fewer people living in an institution (2.1% vs 30.5%, p < .001) and fewer women (61.2% vs 76.7%, p < .000) than the excluded group.

The SNAC-K project was approved by the Regional Ethical Review Board in Stockholm, Sweden. Written informed consent was obtained from all participants. If a person could not answer, a proxy (usually a close family member) was asked for consent.

Data Collection

Data on cognitive, demographic-, health-, and lifestyle-related factors were collected at our centre or the participant's home through interviews, clinical examinations, and testing by nurses and physicians. All data were collected at the same occasion for each participant.

Sociodemographic factors

Information on *age*, *sex*, and *education* (categorized as elementary school, high school, or university) was registered. *Living situation* was categorized as living with someone or living alone.

Lifestyle-related factors

Smoking status was categorized as never, former, and current smoking. *Alcohol intake* was divided into three categories: no or occasional, light-to-moderate (1–7 drinks/wk for women and 1–14 drinks/wk for men), and heavy (≥8 drinks/wk for women and ≥15 drinks/wk for men) (11). Physical activity (PA) was divided into three categories depending on the frequency and intensity of PA during the past 12 months: (i) inactive: less than weekly PA; (ii) health-enhancing: light PA several times per week; and (iii) fitness-enhancing: moderate/intense PA several times per week (12). Weight and height were measured using standard methods. *Body mass index* was calculated by dividing weight in kilograms by height in meters squared, and was categorized as underweight <20, normal 20–24, overweight 25–29, and obese ≥30 (13).

Psychologic and medical factors

Depressive symptoms were assessed by use of the Montgomery-Åsberg Depression Rating Scale (MADRS) (14). The scale has a maximum score of 60, and a score ≥7 indicates depressive symptomology (15). *Cognitive function* was examined using the Mini-Mental State Examination (MMSE), and a score ≤ 27 was defined as cognitive impairment. A cutoff of ≤27 have shown to better identify cognitive impairment among highly educated older adults than the traditional cutoff of 24 (16). The presence of *pain* was assessed with the question, "In the last four weeks, have you experienced pain?" Response alternatives were "yes" and "no." *Chronic diseases* were diagnosed on the basis of a combination of medical records, clinical examination and patient history. A disease was defined as chronic if it was of prolonged duration, left residual disability, worsened quality of life, or required a long period of care, treatment, or rehabilitation. A detailed list of the included diseases is presented elsewhere (17).

Medication use

Fall Risk Increasing Drugs (FRIDs) were defined in accordance with the Swedish National Board of Health and Welfare (18). For a list of fall-risk inducing medications, see Supplementary Table 1.

Mobility and sensory risk factors

Walking speed was assessed by asking the participant to walk 6 m or, if the participant reported walking quite slowly, 2.4 m at a self-selected speed (19), and categorized as: fast > 1.2 m/s, intermediate 0.6–1.2 m/s, or slow < 0.6 m/s/inability to walk (20). *Balance* was measured as the time the participant could stand on one leg. Each leg was tested twice, and the best overall score was used (21). Impairment was defined as a one-leg standing time < 5 seconds (22). *Chair stands* were assessed by asking the participants to stand up and sit down five times as fast as they could, without using the arms (19), and categorized as: faster than 16.7 seconds, slower than 16.7 seconds, or unable to perform the test (23). *Disability* was defined as being dependent on help by another person in one or more of the following Activities of Daily Living or instrumental: bathing, dressing, toileting, transferring/moving, feeding/eating, grocery shopping, cooking, cleaning, doing laundry, managing money, use of telephone, and using public transportation (24). *Vision* was assessed by asking participants if they experienced vision problems. Response alternatives were "yes" and "no." Self-reported visual impairment is considered a valid measure for adverse outcomes among older adults (25,26).

Injurious falls

An injurious fall was defined as hospitalization for or receipt of outpatient care because of a fall (27). Discharge diagnoses from the International Classification of Diseases, Tenth Revision (ICD-10), from the date of the baseline examination until the last available date (December 2011) were used to identify falls. These included the external cause codes W00, W01, W05-W10, and W17-W19, which represent falls on the same level (W00, W01, W18), falls including furniture, wheelchair, etc. (W05-W09), falls from one level to another, for example, from stairs (W10, W17), and unspecified falls (W19). These codes were chosen to represent a low trauma fall without involvement of a second person. This information was retrieved from the National Patient Register, which includes data

Table 1. Description of the Sociodemographic and Lifestyle-related Characteristics Among the Five Different Clusters, in Percentage[a]

	Cluster 1 n = 879, 34.3%	Cluster 2 n = 289, 11.3%	Cluster 3 n = 734, 28.6%	Cluster 4 n = 274, 10.7%	Cluster 5 n = 390, 15.2%	All N = 2,566, n (%)
Gender						
Women	56.2	45.7	59.7	72.6	79	1,571 (61.2)
Men	43.8	54.3	40.3	27.4	21	995 (38.8)
Age						
60–66	75.7	66.8	40.5	11.7	1.3	1,192 (46.5)
72–78	20.8	30.8	48.6	35	15.4	785 (30.6)
81–84	3.5	2.4	10.6	31	31.5	324 (12.6)
87+	0.0	0.0	0.3	22.3	51.8	265 (10.3)
Living with someone						
Yes	60.9	56.7	52.2	34.3	18.2	1,247 (48.6)
No	39.1	43.3	47.8	65.7	81.8	1,319 (51.4)
Education						
Elementary school	5.7	7.3	13.1	24.1	33.6	364 (14.2)
High school	44.6	47.4	49.2	55.8	53.6	1,252 (48.8)
University	49.7	45.3	37.7	20.1	12.8	950 (37)
Body mass index						
Under 20	2.6	1.4	4	8	16.2	141 (5.5)
20–24	48	33.9	30.4	43.1	46.9	1,044 (40.7)
25–29	38.1	57.4	45.6	37.6	28.5	1,050 (40.9)
30+	11.3	7.3	20	11.3	8.4	331 (12.9)
Smoking						
Nonsmoker	44.5	27.7	41.1	55.1	64.4	1,175 (45.8)
Previous smoker	36.1	63	41.4	34.3	31.8	1,021 (39.8)
Smoker	19.4	9.3	17.5	10.6	3.8	370 (14.4)
Alcohol intake						
None or occasional	19	18	26.1	46.7	59.8	772 (30.1)
Moderate	67.9	59.2	63.9	50.4	38.7	1,526 (59.5)
Heavily	13.1	22.8	10	2.9	1.5	268 (10.4)
Physical activity level						
Inactive	16.6	12.8	21	25.9	56.2	627 (24.4)
Health enhancing	49.5	43.6	58.6	66.4	39.2	1,326 (51.7)
Fitness enhancing	33.9	43.6	20.4	7.7	4.6	613 (23.9)

Note: [a]The categories marked in bold are those who contributed significantly ($p < 0.05$) to the formation of each cluster.

from inpatient care and specialized outpatient care, and from the Local Outpatient Register, which includes data from primary care in the Stockholm County Council area (28). Outcome status was determined by linking each participant's personal identification number to the registers. Because of the personal identification number linkage the loss of follow-up data is minimal (29). The Swedish health care registers have been shown to be highly reliable (28). Data on previous falls included injurious falls within 3 years before the baseline examination.

Vital status

Information about the *vital status* of the participants until December 2011 was obtained from the Swedish Cause of Death Registry.

Data Analysis

Clusters were identified using Ward's linkage. Ward´s linkage clustering is a hierarchical agglomerative clustering method that builds on the analysis of variance sum of squares, where the sum of squares within-cluster is minimized (30). This clustering procedure is characterized by the tree-like structure and the clusters are generated according to the characteristics of the subjects and not according to the single variables. In the first step, each subject represents an individual cluster. These clusters are then sequentially merged according to their similarity. First, the two most similar clusters (those with the smallest distance between them) are merged to form a new cluster at the bottom of the hierarchy. In the next step, another pair of clusters is merged and linked to a higher level of the hierarchy, and so on. The number of clusters was chosen based on the balance between intra-cluster similarity and inter-cluster variance, and a combination of studying tree diagrams and proportions of each factor included was used.

We used flexible parametric survival models to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) for the association between the different clusters and injurious falls. Participants were considered at risk from the date of the baseline examination. Risk of injurious falls was analyzed, censoring the observation time at three different points in time: 3, 5, and 10 years after baseline or at the date of death (172 participants died within 3 years of baseline, 329 within 5 years, and 694 within 10 years). The Population Attributable Risk of injurious falls was calculated by using the formula for survival studies to estimate the proportion of injurious falls averted in the hypothetical scenario that we would be able to eliminate the specific cluster of risk factors. To explore possible age- and sex differences between risk of injurious falls between the clusters, we also run the analyses stratifying by sex and age. An additional analysis was conducted excluding individuals living in a nursing home. Finally, the effect of missing values was evaluated by performing imputations of 15 imputed datasets using multiple imputations chained equations (31). We pooled the estimates using Rubin's rule to obtain valid statistical inferences. All the relevant variables included in the main analysis, including the outcome, were used in the multiple imputation models. Statistical analyses were performed with version 14 of Stata software (StataCorp, TX).

Results

The cluster analysis identified five major clusters of risk profiles for falls. Tables 1 and 2 show the characteristics of the participants in the different clusters. Of all participants, 54 (2%) lived in a nursing home (none of the individuals in Cluster 1, 1.9% in Cluster 2, 11.1% in Cluster 3, 7.4% in Cluster 4, and 79.6% of the individuals in Cluster 5).

Cluster 1: "Healthy" (*n* = 879, mean age 65.8 ± 6.3, 56.2% women)

In this cluster, the younger participants were over-represented (75.7% 60–66 years old). Most people were living with someone and were highly educated. A large proportion of participants was nonsmokers, normal- or overweight, physically active, and had moderate alcohol consumption. Furthermore, most people were free from chronic diseases, pain, cognitive and physical impairment, depressive symptomology, disability, and used no FRIDs. This cluster was used as the reference group in the survival models.

Cluster 2: "Well-functioning with multimorbidity" (n = 289, mean age 67.3 ± 6.5, 45.7% women)

Cluster 2 is similar to cluster 1 in terms of age, cohabitation status, education, body mass index, physical activity, FRIDs, cognitive and functional status. Relative to the whole population, this cluster had the highest proportion of previous smokers, most heavily drinkers, and the highest proportion of men. Furthermore, the prevalence of pain and chronic diseases were higher than in cluster 1 (only 2.4% had no chronic disease).

Table 2. Description of the Medical and Psychological Factors, FRIDs, Sensory and Mobility Factors Among the Five Different Clusters, in Percentage[a]

	Cluster 1 *n* = 879, 34.3%	Cluster 2 *n* = 289, 11.3%	Cluster 3 *n* = 734, 28.6%	Cluster 4 *n* = 274, 10.7%	Cluster 5 *n* = 390, 15.2%	All N = 2,566, *n* (%)
Problems with vision						
Yes	38.1	55.4	52	48.9	64.4	1,262 (49.2)
No	61.9	44.6	48	51.1	35.6	1,304 (50.8)
Pain						
Any pain last 4 wk	23	36.7	41.3	38.7	47.9	904 (35.2)
No pain last 4 wk	77	63.3	58.7	61.3	52.1	1,662 (64.8)
Depressive symptoms						
Less than 7	95.1	92.7	84.2	93.8	79.2	2,288 (89.2)
7+	4.9	7.3	15.8	6.2	20.8	278 (10.8)
MMSE score						
Less than 28	4.2	8.7	9	21.5	39.5	341 (13.3)
28+	95.8	91.3	91	78.5	60.5	2,225 (86.7)
Chronic diseases						
None	62.3	2.4	1.6	15.3	0.8	612 (23.9)
1	32.7	34.6	26	43.8	15.1	758 (29.5)
2+	4.9	63	72.4	40.9	84.1	1,196 (46.6)
FRIDs						
None	88.8	64.7	3.7	75.2	7.7	1,230 (47.9)
1	11	31.8	26.7	22.6	23.6	539 (21)
2+	0.2	3.5	69.6	2.2	68.7	797 (31.1)
ADL and/or IADL						
No dependencies	99.3	94.8	90.3	84.7	44.1	2,214 (86.3)
1+	0.7	5.2	9.7	15.3	55.9	352 (13.7)
Walking speed						
Less than 0.6 m/s	0.4	0.4	4	15	52.1	277 (10.8)
0.6–1.2 m/s	55.6	60.9	76.8	80.3	47.2	1,633 (63.6)
1.3 m/s or faster	44	38.7	19.2	4.7	0.7	656 (25.6)
Balance						
Less than 5 s	7.4	8.7	24.4	60.2	83.6	760 (29.6)
5 s or more	92.6	91.3	75.6	39.8	16.4	1,806 (70.4)
5 time chair stand						
Not able to	0.3	0.7	5.9	30.3	56.7	351 (13.7)
16.7 s or longer	7.7	10.7	18.5	35.4	24.6	428 (16.7)
Less than 16.7 s	92	88.6	75.6	34.3	18.7	1,787 (69.6)
Previous injurious falls						
No	97.5	97.2	94.3	89.4	81.5	2,393 (93.3)
Yes	2.5	2.8	5.7	10.6	18.5	173 (6.7)

Note: ADL = Activities of daily living; IADL = Instrumental activities of daily living; FRID = Fall-risk increasing drugs; MMSE = Mini-Mental State Examination.

[a]The categories marked in bold are those who contributed significantly ($p < 0.05$) to the formation of each cluster.

Cluster 3: "Well-functioning, with multimorbidity and high FRID consumption" (n = 734, mean age 71.5 ± 7.5, 59.7% women)

This cluster includes the highest proportions of obese people and people using FRIDs. A high proportion was smokers, had depressive symptomology, and the majority had two or more chronic diseases. Most people scored medium to high in the physical tests, were functionally independent and without cognitive impairment.

Cluster 4: "Physically and cognitively impaired" (*n* = 274, mean age 79.8 ± 8.3, 72.6% women)

Cluster 4 includes people from all age groups. They were generally healthier than people in Cluster 3 in terms of fewer chronic diseases and FRIDs. Relative to cluster 1–3, they generally had lower scores in physical function and a higher rate of cognitive impairment (21.5%). Few people in this cluster were smokers, heavy drinkers, or engaged in fitness-enhancing physical exercise.

Cluster 5: "Disabled" (*n* = 390, mean age 85.6 ± 6.1, 79.0% women)

Cluster 5 includes mainly the oldest old and a majority were women. More than 50% were disabled and had low scores on physical tests. This cluster had the highest proportion of vision problems, pain, depressive symptomology, underweight, chronic diseases, and cognitive impairment.

Association With Injurious Falls

Of the 2,566 participants, 599 were hospitalized or received outpatient care at least once because of a fall over a 10-year follow-up (mean follow-up 6.47 ± 3.2 years), including180 during a 3-year follow-up period (mean follow-up 2.67 ± 0.75 years) and 327 during a 5-year follow-up period (mean follow-up 4.13 ± 1.5 years). The consequences of the injurious falls are presented in the Supplementary Table 2. Results from the survival analysis are shown in Table 3. The risk of experiencing an injurious fall doubled for each cluster over 3 years of follow-up. This trend remained stable through the different follow-up times for Cluster 2 and 3 while the hazard ratio decreased over time for Cluster 4 and 5.

In total, approximately 50% of the injurious falls were estimated to be attributable to the different risk factors included in the clusters, the proportion for cluster 2–5 individually were; 5%, 21%, 9%, and 14%, respectively (Figure 1). The results from the stratified analysis showed similar results for men and women (Supplementary Figure 1), and the same trend for different age groups (Supplementary Figure 2). The sensitivity analysis with imputed data showed similar results as those presented in Table 3, suggesting that the missing data did not introduce any significant bias in the results (Supplementary Table 3). In addition, the sensitivity analysis excluding individuals living in a nursing home showed similar results (not shown).

Discussion

In this population-based study of Swedish older adults, five risk factor groups were identified: "healthy", a "well-functioning with multimorbidity", a "well-functioning, with multimorbidity and high FRID consumption", a "physically and cognitively impaired", and a "disabled" cluster. Overall, we observed a gradient increase in the risk of injurious falls for people in the second to fifth cluster compared to those in the first cluster. The gradient difference between the clusters was found both in a short (3 years), medium (5 years), and long (10 years) follow-up time.

Consistent with previous studies (9), we found that people with unhealthy lifestyle and a high burden of chronic disease, that is, cluster 2, had an increased risk of falling over a longer period of follow-up (5 and 10 years), compared to those in the reference group. Indeed, the risk of falls have been shown to increase with the number of chronic diseases (4,32). Our results also clearly indicated that these factors may increase the risk of injurious falls even in quite well-functioning individuals. One explanation for this finding could be that presence of chronic disease is often the initial phase of the process leading to impairments and functional dependence (33). Thus, it is possible that people with unhealthy lifestyle and chronic diseases will develop physical and cognitive impairments over time, which in turn increase the risk of injurious falls.

Cluster 3 included quite well-functioning individuals with high proportions of chronic diseases, FRIDs, and depressive symptoms. Both depressive symptoms (34) and use of FRIDs (35) have been consistently associated with an increased risk of falls in population-based studies. The fact that they cluster together might be explained by the inclusion of antidepressants and other psychotropic medication in the definition of FRIDs (18). The excess risk of falling for people in Cluster 3 compared to those in Clusters 1 and 2 may reflect the importance of FRIDs and chronic diseases as fall risk factors, and may also suggest that addressing older people's mental health could help to improve overall health status (36).

Cluster 4 was characterized by a high proportion of people with physical and cognitive impairments. Although people in this group generally had fewer chronic diseases and used fewer FRIDs than people in Cluster 3, their risk of injurious falls was twice as high. Indeed, physical and cognitive impairments are considered as key risk factors for falls in older adults (4,27). Our findings from this cluster further support the view that physical and cognitive deficits are strongly interrelated in aging (37,38) and that cognitive

Table 3. HRs with 95% CIs for the Associations Between the Different Clusters and Injurious Falls Over 3, 5, and 10 y of Follow-up Time, Derived from Flexible Parametric Survival Models

	3 y		5 y		10 y	
Clusters	Number of Fallers	HRs (95% CI)	Number of Fallers	HRs (95% CI)	Number of Fallers	HRs (95% CI)
Cluster 1 (*n* = 879)	16	Ref.	38	Ref.	104	Ref.
Cluster 2 (*n* = 289)	10	1.93 (0.87–4.25)	21	1.74 (1.02–2.66)	46	1.44 (1.02–2.04)
Cluster 3 (*n* = 734)	46	3.56 (2.01–6.28)	91	3.06 (2.10–4.47)	187	2.54 (2.00–3.23)
Cluster 4 (*n* = 274)	34	7.32 (4.04–13.26)	63	6.19 (4.14–9.26)	101	4.21 (3.20–5.53)
Cluster 5 (*n* = 390)	74	12.67 (7.38–21.75)	114	9.72 (6.73–14.03)	161	6.85 (5.34–8.78)

Note: CI = Confidence interval; HR = Hazard ratio.

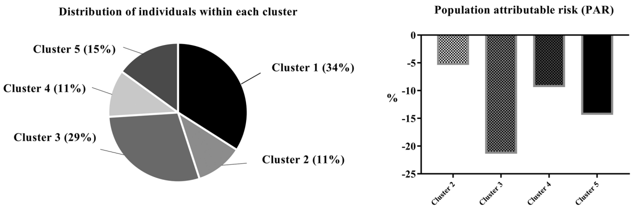

Figure 1. Distribution of individuals in each cluster (in percentage) and the proportion of injurious falls averted if a specific cluster of risk factors was removed.

impairment might add to the risk effect of physical impairment on injurious falls (27,39–41).

The individuals at highest risk for injurious falls were in Cluster 5. These individuals had a combination of many of the risk factors, such as cognitive and physical impairment, disability, depressive symptoms, low PA, several chronic diseases, and use of several FRIDs. This group emphasizes the importance of a multifactorial perspective, that the people at the highest risk do not have one or two risk factors—but several of them—and need a holistic approach to reduce the risk of falls (42).

The distribution of the age groups followed an expected pattern, with the oldest people in the clusters with the highest risk for injurious falls (4). However, people from most age groups were represented in all five clusters, emphasizing the importance to view the risk of falling from a person-centered perspective, by considering the complexity and between individual heterogeneity of risk of falling.

The Population Attributable Risk analysis shows that about 50% of the injurious falls were a consequence of the risk factors present in cluster 2–5. Considering that the risk of falls may also depend on environmental and unpredictable factors, this proportion is encouraging and suggests that tailored interventions could be effective to prevent falls.

With our study design, it is not possible to draw conclusions of the specific effects of each risk factor, or on the mechanisms behind the observed associations. The focus on this study was however on the patterns of risk factors (in contrast to the effect of individual factors), which so far has been rarely studied. Our finding of a gradient difference in risk of injurious falls between the people in the different clusters suggest that it may be possible to identify groups of older adults at different levels of risk, which may help us improve fall-prevention strategies. For instance, people at high risk (cluster 4–5) may be optimal targets for multifactorial interventions (42). In addition, detection of people at moderate risk (cluster 2–3) can help clinicians identify older adults who may benefit from primary interventions, such as physical exercise, or medication reviews (43). However, further research is needed to determine which combinations of risk factors best predict injurious falls in older adults and thus should be included in the screening to identify groups of older adults at medium and high risk of injurious falls.

Strengths of this study include the large community-based sample of older people and the long follow-up time, which enabled us to examine risk over varied follow-up periods. Moreover, we employed objective testing of several factors and we used different sources of medical diagnoses, including direct clinical examination; thus limiting potential biases. However, a few variables were self-reported (eg, vison), and although a mixture of measured and self-reported risk factors are commonly included in studies on fall risk (4), this may present a limitation of the study. Furthermore, our outcome was an objective measure of injurious falls from high quality register data, Bergström et al. found that more than 98% of all hospitalizations due to falls were correctly coded (28). A limitation of the study, however, is that less severe falls were most likely not captured, which may have led to an underestimation of the outcome. Furthermore, although the outcome was injurious falls, the consequences of the falls were unspecified in 6–12% of the cases. Thus, we do not know whether or to what extent those falls resulted in an injury. Other limitations of the study are the relatively healthy, well-educated sample of older people, which may limit the generalizability of the results to quite well-functioning older populations.

In summary, this study suggests that risk factors for falls appear in different clusters. To be in a high-risk cluster increases the risk of experiencing an injurious fall between 7 and 12 times compared to being in a low-risk cluster. Individuals with these combinations of risk factors should be the target of interventions to prevent falls. In addition, the combination of risk factors in the middle risk clusters might be the optimal targets of primary prevention with a more general healthy aging approach, for example by addressing life-style factors.

Supplementary Material

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

Funding

SNAC-K is supported by the Swedish Ministry of Health and Social Affairs and the participating county councils and municipalities. This study was further supported by the Swedish Research Council (grant number 521-2014-21-96).

Acknowledgments

The authors thank all the SNAC-K participants for their invaluable contributions and our colleagues in the SNAC-K group for their collaboration in data collection and management.

Conflict of Interest

The authors have no conflicts of interest.

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