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The nature and the geography of elderly injuries in Sweden

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Abstract This study assesses the nature and the geography of elderly injuries in Sweden. The most dominant types of accidents affecting the elderly in their homes and near environments are identified by using county-specific data from 2001 to 2010 followed by a correlation analysis of possible environmental factors underlying patterns of falls among the elderly. Geographical information systems are used to map rates by type. Slipping, tripping and stumbling are the causes of more than half of cases of elderly falls in Sweden, and is more typical in the Northern counties. Findings also show there has been a rise in rates of elderly falls since 2001 in most of the Southern counties, especially in Östergötland and Skåne Counties. Population age and gender affect the ecology of geography of fall rates and counties experiencing long cold winters tend to show higher rates of indoor falls than those with warmer temperature across the year. The article finalizes with a discussion of the results and implication for future research.

Keywords Elderly injury · Geography of fall · Spatial patterns · Seasonal temperature variation

Introduction

Falls among the elderly[1] is an increasing global public health issue. Sometimes a simple fall can result in severe medical conditions and even death. Even if a fall does not affect the physical health of senior citizens, it may affect their future mobility as they become fearful of falling (Nevitt et al. 1989; Tideiksaar 1996; Chan et al. 2012). In Sweden, more than two-thirds of all fatal injuries occur among elderly citizens, with an annual cost to the society amounting to 11 billion SEK (Torstensson et al. 2011). Nineteen percent of the current population is over 65 and by 2020, a fourth of the population will be older than 65 (Schyllander and Rosenberg 2010).

A fall is a product of complex interaction between multi-dimensional factors. These include behavioral, environmental, biological and socioeconomic factors that impact on individual vulnerability to falls. Moreover, place of residence influence the rates of fall (Chan et al. 2012; Wågert et al. 2009). Johnel et al. (1992) suggest the existence of geographic differences in elderly falls across continents. Gullberg et al. (1997) found that falls that resulted in hip fractures were most common in Northern Europe and North America, possibly because of weather and environmental variations. Furugren and Laflamme (2007), in their study

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[1] According to WHO (2008), the chronological age of 65 years has been accepted as a definition of 'elderly' or older persons in most of the developed world.

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on the significance of country of birth in prevalence of falls among Swedish elderly, argue that incidences of hip fractures are significantly more common among native Swedes than among the foreign-born elderly population.

Previous research on the geography of health has often shown how a health outcome corresponds to the spatial variation of risk factors (Anthamatten and Hazen 2011). Yet for many health researchers, "this tradition still remains an exploratory tool with little applied value and despite the usefulness of geographic knowledge, the spatial character of fall injuries in the elderly remains largely unknown" (Yiannakoulias et al. 2003: 2068). Few would deny the value of geographic approaches to health as they have a variety of applied and theoretical uses: they can offer important exploratory evidence about otherwise unknown risk ecological factors, and in particular, factors which are inherently geographic in nature.

Place, time, and person are three characteristics used to organize and summarize the data in descriptive epidemiology to have better understanding and more detailed information of the health population. For instance, injury rates change regularly (predictable) or irregularly (unpredictable) over the time. Injury rates could also be described by place or a geographical unit such as place of birth, place of residence, district, and so on. When it comes to person, the data can be analyzed based on inherent characteristics of the population (sex, ethnicity, and age), acquired characteristics (marital status), etc. Such knowledge can aid efforts to more efficiently identify persons at particularly high risk of falls, and improve the effectiveness of intervention strategies.

This study makes a contribution to the knowledge base on the geography of falls using Sweden as a case study. The study assesses the geography of elderly falls in Sweden by investigating the presence of the geographic differences of falls among the elderly using county-based data on the external causes of fall injuries. The study also examines the presence of association between elderly falls and gender, age, temperature variations, and housing type at county level. Studies on injury rates in Sweden vary regarding the case study and the population of interest. Some studies examine the influence of geographic variations on injuries among childhood populations as opposed to senior citizens, or focus on a specific form of the injury (Ekman et al. 2001, 2005; Emanuelson and Wendt 1997; Andersson et al. 2003; Johansson et al. 1991; Kleiven et al. 2003). Little evidence is found about elderly falls by county level, while many studies consider the country as a single unit (Ekman et al. 2005).

Sweden constitutes an interesting case study in the analysis of elderly falls. A growing proportion of the Swedish population is elderly and still lives in their homes, with relatively independent lifestyles. In most of the European countries, the elderly mortality rate as a result of unintentional injuries has reduced over the past 8–10 years. In Sweden (despite the low elderly mortality rate as a result of unintentional injuries), although the overall rate of elderly mortality has remained constant, there is a decrease in mortality rates as a result of fall and motor vehicle traffic injuries. While the mortality rate for smoke, fire, and flame, as well as poisoning, and drowning injuries show an increasing trend (Petridou et al. 2008). Moreover, Sweden, the third largest country in Western Europe, is located in Northern Europe on the Scandinavian Peninsula. The country's long North–South length offers some seasonal variation in terms of temperature and humidity. For instance, the Arctic Circle of Northern Sweden has long cold winters (−15 °C) and longer dark hours, while winter in the South is usually mild (with an average yearly temperature above 0 °C). These temperature differences affect individuals' lifestyles and consequently, their risks of falling.

Theory and hypotheses

Falls are related to the fact of being in advanced age (Prudham and Grimley-Evans 1981; Campbell et al. 1981; Wild et al. 1981). Additionally, gender (Prudham and Grimley-Evans 1981; Craven and Bruno 1986; Tinetti et al. 1995b; Lehtola et al. 2006), the use of medication (Prudham and Grimley-Evans 1981; Neutel et al. 1996; Teno et al. 1990; Vitry et al. 2010; French et al. 2007) and previous fall history may heighten the risk of falling. Moreover, engaging in specific activities such as stair climbing (Tinetti et al. 1995a; Waller 1978; Verghese et al. 2008) night urination or having cognitive impairment may increase the risk factor (Yasumura et al. 1994; Stewart et al. 1992; Nevitt et al. 1989; Prudham and Grimley-

Evans 1981; Beauchet et al. 2008; Chen et al. 2011). Further, physical or mental limitations (Campbell et al. 1981; Tinetti et al. 1988; Gabell et al. 1985; Yasumura et al. 1994) and the use of mobility aids may increase the risk of falls (O'Loughlin et al. 1993; Blake et al. 1988). The results of a study conducted by Reinsch et al. (1993) indicated that the activities necessary for independent living represented 40 % of all fall incidents, of which getting up from bed/chair, climbing up/down stairs, turning (also sitting down), reaching out for something accounted for the highest risk-taking behaviors. On the other hand, participation in sporting activities or climbing on chairs or ladders accounted for a small share of fall incidents (Tinetti et al. 1988). Berg et al. (1997) explain that trips and slips represent 59 % of fall causes. Additionally, collision with furniture while walking in the dark is another common cause of falls (Connell and Wolf 1997).

Falls are the most common injuries experienced by the older population (Alptekin et al. 2008; Scott and Gallagher 1999; Parry et al. 2001; Sattin et al. 1990; Evect et al. 2006). Even within older age groups, the risk of falls varies. Luukinen et al. (1994) suggest that the rates of falls tend to be higher in cases where the elderly living in ordinary homes encounter disabling diseases or as a result of normal aging processes in Finland. The results of another Finnish study indicate that the elderly, especially older men are more likely to falls as they age (Lehtola et al. 2006). However, some other studies concerning gender differences in falls reveal that elderly women are more at risk of falling than men (Yasumura et al. 1994; Marcela and Dourado 2012; Stevens and Sogolow 2005). Saveman and Björnstig (2011), in their study on unintentional injuries among elderly population in north of Sweden, show that senior citizens aged 85 years and older are three times as likely as those aged 65–74 to experience injuries. Older women are also more prone to be injured than men. *It is expected that the current case study shows similar gender and age patterns—that women are more exposed to falls than men and that the older they are, the higher the likelihood of falling at county level.*

Studies assessing weather variations in the prevalence of fall incidents show inconclusive results (Bulajic-Kopjar 2000). Some studies indicate that freezing temperature increases the risk of slipping (Rális 1981; Manning et al. 1982; Rális 1986). Studies in Australia (Lau et al. 1995), the US (Jacobsen et al. 1991), Norway (Bulajic-Kopjar 2000), and Sweden (Holmberg and Thorngren 1987) found that the areas associated with long cold winters have more cases of falls (Lin and Xiraxagar 2006; Levy et al. 1998; Mirchandani et al. 2005). Bergstralh et al. (1990) argue that limited access to sunlight, especially in winter, may result in poor visual acuity and inadequate levels of vitamin D, which are the potential risk factors for falls. In other studies, no associations have been found between fall events and temperature (Rowe et al. 1993). Bulajic-Kopjar (2000) suggests that the lack of evidence in relation to seasonal variations and its effect on falls may be explained by the climate of each country. The probability of seasonal effects is less in regions with mild winter temperature. As earlier indicated, temperature in Sweden varies from the North to the South. For instance, the coolest average temperature in winter in 2005 is between −20 °C in North and −1 °C in South of the country.

The reported rates of injury incidents also vary between countries, the counties comprising a country (Falch et al. 1993; Finsen et al. 2004) and between rural and urban areas. Their geographical location (e.g., yearly average temperature) affects elderly mobility patterns and therefore fall rates. Studies in Australia (Lau et al. 1995), USA (Jacobsen et al. 1991), Norway (Bulajic-Kopjar 2000; Lofthus et al. 2001) and Sweden (Holmberg and Thorngren 1987; Kleiven et al. 2003) evidenced a seasonal pattern of falls. In Europe, the rates of head injuries vary from North to South, with the highest rates reported among countries in Southern Europe, and the lowest in Scandinavian nations (Heskestad et al. 2009). However, there are regional variations by types of injuries. A Swedish study (Kleiven et al. 2003) reported an annual average rate of head injuries that was almost three times high in comparison to a Norwegian study (Andelic et al. 2008). The highest incidence of hip fractures in Europe has been reported in Scandinavian countries (Falch et al. 1993; Bjorgul and Reikeras 2007; Finsen et al. 2004), and particularly in Oslo, Norway's capital (Lofthus et al. 2001). *Therefore, it is hypothesized that there is a relationship by county between the rates of falls and seasonal temperature variations across Sweden at county level.*

Overall, the elderly spend most of their time (about three-quarters of their daytime) at home and in their

immediate environments (Oswald and Wahl 2005). Senior citizens like to get a sense of familiarity with their environment and to independently complete their tasks. As a result, they are more likely to live in the same place for a long time (Motel et al. 2000). This makes the older population more vulnerable to environment changes and often due to their health limitations (Wahl and Oswald 2010). Previous research shows that older people with disabilities, poor health conditions, and inactive lifestyles spend most of their time at home, and consequently are more exposed to indoor falls (Kelsey et al. 2010). Conversely, those with better health conditions and active lifestyle are at a higher risk of outdoor falls (Kelsey et al. 2010). Other studies suggest that 'vigorous older people' are also more likely to fall when they are active in or around the houses or due to exposure to environmental hazards (Isaacs 1985; Northridge et al. 1995; Speechley and Tinetti 1991; Mackenzie et al. 2002; Baldwin et al. 1996). Thus, the living environments and the conditions of the elderly housings could be crucial areas to investigate. For instance, the types of activities taken by the elderly living in apartments and multi-family housing could be different from those activities taken by the older population living in the single family housing. Living in single family housing is often associated with gardening, and more outdoor activities which may be regarded as risky activities for fall. *Thus, it is also expected that in Sweden, counties that have the elderly population living in single-family houses are the ones that show higher rates of falls than those counties where the elderly live in other types of houses.*

Data and method

Statistics on the elderly falls were collected from The Swedish National Board of Health and Welfare based on ICD-10 classification of the external causes of fall (W00–W19). In order to identify the growth rate of falls over the past decade, a period from 2001 to 2010 was examined. The population of interest involved the elderly who experienced falls that resulted in hospitalization (in-patient records). The database can be sorted by year (2001–2010), gender, age group, and counties (where the patients live). The external causes of fall injuries were categorized into twenty groups from W00 to W19. In order to utilize more homogenous data, some of the fall codes were aggregated. First, 'Fall in the same level by slipping, tripping or stumbling' (W01). The codes W00 ('Fall on same level due to ice and snow') and W02('Falls in connection with the use of ice skates, skis, roller skates, skateboard or snowboarding') were aggregated in one group entitled 'Fall in ice and snow and in connection to ice skate/board equipment. Another group includes W05 ('Fall from wheelchair'), W06 ('Fall from bed'), W07 ('Fall from chair'), and W08 ('Fall from other furniture') and is called 'Fall from furniture'. The third group consists of the codes W11 ('Fall on and from ladder'), W12 ('Fall on and from scaffolding'), and W13 ('Fall out of or through building or building structure') in the name of 'Fall from ladder, scaffolding, or building'. 'Fall in and from stairs and steps' (W10), and 'Unspecified Fall' (W19) was used in the final analysis. Unspecified fall is a category that is used when the cause of an fall injury is unclear (for instance no one witnessed the fall) but it is clear that the person has fallen. An interview was also conducted with Anders Jacobsson, a statistician in The Swedish National Board of Health and Welfare, about the injury records that are not included in this data due to the missing external causes of injury.

Another database from The Swedish National Board of Health and Welfare identified the place where the elderly were most likely to experience falls. Although these databases could not be merged, they provided a complementary picture of types of elderly falls. The database includes the number of patients admitted in hospital based on county, age group, gender—regardless of the external causes of fall incidents. Nine locations (0: Housing and immediate environment, 1: Institutional accommodation, 2: School, other institution and public premises, 3: Athletic and sports facility, 4: Street and road, 5: Retail trade or service area, 6: Industrial construction, 7: Farming Zone, 8: Other specified places, 9: Location unspecified) were identified in this database. These fall groups have also been aggregated into three main categories to identify indoor and outdoor falls. The first one includes falls in homes and home environments, the second group contains falls on the street and farming zones and the third one covers the rest of the falls.

The data sets used to identify the environmental characteristics of Swedish counties include counties

population, counties housing type,[2] and counties temperature data.[3] Counties population data is available on Statistics Sweden webpage, by year, county, sex, and age group. Housing type data contains the number of single and multifamily housing available in each county in 2010 and was derived from Statistics Sweden. The temperature data includes the minimum, average, and maximum temperature of the year by county from 2001 to 2010—derived from the Swedish Meteorological and Hydrological Institute. In addition, the study makes use of records on the minimum/maximum temperature of the capital city of each county in winter/summer—available on the internet.

Analysis of elderly falls

Rates of falls per 100,000 elderly populations were calculated using the population data of each county by age and sex. Fall rates were calculated as follows:

$$Rate\ of\ falls = \frac{Number\ of\ elderly\ faller\ at\ a\ county}{Total\ elderly\ population\ of\ that\ county} \times 100,000 \quad (1)$$

As Eq. 1 shows, in order to calculate the age and gender specific rate of falls in each area, the number of elderly fallers relevant to a specific group (for instance elderly women) was divided by the total elderly population in that specific group (total population of elderly women).

Geographical information systems (GIS) were employed to map the rate of falls, which helped to identify the counties with the highest/lowest fall rates and the fall growth rates. A geo-relational database was built using a map by Counties and attribute tables for fall types and totals as well as other county level statistics.

The Fisher Exact Test was used to explore potential associations between, for instance, the rate of elderly falls and the minimum yearly temperature as well as the minimum temperature of the counties. The Fisher Exact Test is appropriate for small samples (the number of Swedish counties is 21) as opposed to Chi square test to check dependency between variables. Based on the median of each variable, fall rates, the minimum yearly temperature, and the minimum winter temperature, Swedish counties were ranked from low to high. For instance, if the median of the fall rates was 2,731.9 per 100,000 elderly populations, the fall rates of the counties higher/lower than 2,731.9 were classified as high and low respectively. The Fisher Exact Test analysis was performed on all fall groups except the unspecified falls using statistical software.

To have the direction and the magnitudes of the significant associations derived by the Fisher Test, Spearman's Rank Correlation was employed, as Fisher Test fails to indicate the directions and magnitudes of the associations.

Study area

In Sweden, people aged 65 and above are defined as older adults. Swedish senior citizens accounted for 19 % of the country's population in 2012, and the proportion of older women was higher than men's (Statistics Sweden, 2012). In 1999, the percentage of the Swedes elderly who die as a result of falls stands at 80 % as compared to the percentage of older adults (17 %) who die as a result of the other injries (Berleen 2004).

Counties are the largest subdivisions in Sweden. Table 1 contains the elderly population numbers and selected environmental factors of Sweden counties. The rate of growth of the elderly population has greatly exceeded the growth rate of the country's total population from 2001 to 2010. While the total Swedish population increased by 5.7 % from 2001 to 2010, the elderly population increased by 13.4 %. As shown in Table 1, Uppsala, Halland, and Gotland counties respectively had the highest elderly population growth rate from 2001 to 2010. The migration of young people from rural and semi urban areas to more urbanized cities such as Stockholm as well as the risk of death among the elderly in each county might be the underlying causes of this pattern. The number of older women was higher than older men in all Swedish counties in 2010. The older population was mostly concentrated in the South (Stockholm, Västra Götlands, Skåne, and Östergötlands). Counties with the highest number of elderly females also had the highest number of elderly males.

[2] http://www.scb.se/.

[3] http://www.smhi.se/.

Table 1 Elderly population and selected environmental characteristics by county

County	No. of elderly population 2001	No. of elderly population 2010	Elderly population growth rates (%) 2001–2010	Share of Swedish elderly born (%)	Minimum yearly temperature (°C)	Minimum temperature in winter (°C)	Single family housing (%)	Paved county road (%)*	Population per distance class to the nearest grocery store (%)			
									Less than 5 min	5–10 min	10–30 min	More than 30 min
Blekinge	29,281	33,352	13.9	93.1	4.4	−10.0	57	89	90.5	8.8	0.7	0
Dalarna	54,569	59,865	9.7	92.5	1.4	−11.0	57	75	85.46	12.14	2.37	0.02
Gävleborg	54,871	59,521	8.5	94.3	1.4	−5.0	52	84	87.29	10.08	2.63	0
Gotland	10,247	12,220	19.3	95.6	4.4	−4.3	64	100	74.49	20.62	4.89	0
Halland	48,378	58,638	21.2	91.3	4.8	−4.0	63	93	89.67	9.54	0.79	0
Jämtland	25,600	26,841	4.8	95.7	0.5	−10.0	52	57	80.23	13.05	6.62	0.1
Jönköping	59,845	65,374	9.2	91	1.9	−7.3	53	86	87.34	10.53	2.13	0
Kalmar	47,386	52,396	10.6	93.8	3.5	−4.0	58	92	87.09	10.61	2.3	0
Kronoberg	32,905	36,549	11.1	91.2	3.6	−4.0	57	85	83.57	13.42	3.01	0
Norrbotten	46,425	52,395	12.9	91.3	−1	−16.0	51	58	86.15	8.26	5.27	0.31
Örebro	50,048	55,404	10.7	90	1.8	−4.0	47	70	88.72	9.47	1.81	0
Östergötland	72,406	81,227	12.2	91.7	3.4	−7.0	43	81	88.27	9.54	2.19	0
Skåne	200,185	228,263	14.0	87.2	5.5	−3.0	46	89	95.01	4.93	0.06	0
Södermanland	47,059	55,456	17.8	86.8	3.1	−6.0	46	77	84.88	12.93	2.19	0
Stockholm	259,279	307,143	18.5	80.7	4.9	−5.3	27	98	96.67	2.9	0.43	0
Uppsala	42,286	55,476	31.2	89.3	1.9	−7.4	42	80	86.75	11.6	1.64	0
Värmland	54,606	59,145	8.3	91.4	2.1	−9.0	55	66	84.31	11.87	3.82	0
Västerbotten	44,380	49,558	11.7	96.1	−1	−11.0	49	56	82.72	10.68	6.49	0.12
Västernorrland	49,431	53,011	7.2	95.5	−0.15	−15.0	52	57	84.72	10.84	4.45	0
Västmanland	46,468	50,862	9.5	82.5	3.2	−1.0	43	78	89.52	8.99	1.49	0
Västra Götaland	256,409	284,550	11.0	87.6	3.3	−5.0	45	83	90.7	8.37	0.93	0
Sweden	1,532,064	1,737,246	13.4		–	–	–	76	90.50	7.87	1.61	0.01

Data source Statistics Sweden, 2001–2010. Swedish National Board of Health and Welfare, 2010. The Swedish Meteorological and Hydrological Institute, 2001–2010, Growth Analysis, 2010

Physical activity among the elderly, especially outdoors, can be highly affected by the weather. Sweden can be divided into three types of climate; the southernmost part experiences an oceanic climate, the central part experiences a humid continental climate, while the northernmost part has a subarctic climate. In winter, the minimum temperature may vary from −16 °C in the Northern counties to −3 °C in the South. This may imply that counties in the North are associated with the long lasting snow cover in winter in comparison to the southern counties. The maximum yearly temperature also differs—from 6.7 °C in north and 12.6 °C in the South.

Housing type may differ from single family housing and multi-family housing in Sweden. Gotland and Halland counties have the highest number of single family housing. Essentially, the type of housing should be an indicator of the elderly population's physical activity and their risk of falling. Here this is measured by the share of single family housing versus multifamily housing available in Swedish counties.

Results

The nature of elderly fall

The most dominant cause of elderly falls in Sweden counties is slipping, tripping and stumbling (57 %). In addition, as many as 25 % of elderly falls were recorded as 'without any specific causes'. The third common cause of falls is 'Fall on same level' due to ice and snow (4 %), which can also belong to the first category of falls. Diving or jumping into water is the least likely cause of falls among the elderly (only three cases were reported in the whole country), followed by falls from a cliff (0.02 %) and falls from playground equipment (0.01 %) at county level.

Table 2 shows the rate of elderly falls per 100,000 populations, based on age, gender and external causes of fall at county level. In Sweden counties, as older adults continue to age, they are more prone to falls resulting from slipping, tripping and stumbling, falling from furniture or from stairs and steps. These falls mostly occur indoors. As expected, as senior citizens get older, they tend to spend most of their time indoors and are more likely to fall in these environments. Thus, with less physical activity, rates of outdoor falls on and

Table 2 The rate of elderly fall per 100,000 older populations, by sex, age, causes of fall in 2010

Age groups	Falls due to ice and snow, and in connection to ice skate/board equipment			Falls caused by tripping, slipping or stumbling			Falls from furniture			Falls from ladder, building, scaffolding			Falls from stairs and steps		
	Both sex	Female	Male	Both sex	Female	Male	Both sex	Female	Male	Both sex	Female	Male	Both sex	Female	Male
65–69	103.4	133.5	74.0	440.0	542.0	338.0	33.2	34.3	33.0	48.4	14.3	84.0	33.2	34.3	33.0
70–74	118.3	139.5	95.0	725.0	894.0	543.0	56.7	63.0	49.0	46.1	15.5	81.0	56.7	63.0	49.0
75–79	141.9	155.0	126.0	1,357.0	1,637.0	1,013.0	97.3	113.4	80.0	43.7	19.0	76.0	97.3	113.4	80.0
80–84	165.5	171.0	159.0	2,588.0	3,029.0	1,949.0	200.0	221.0	173.0	33.3	13.0	64.0	200.0	221.0	173.0
85+	142.8	132.0	166.0	5,374.0	6,020.0	4,075.0	399.0	421.0	361.0	19.6	14.0	30.0	399.0	421.0	361.0
Total	127.7	144.0	110.0	1,694.0	2,158.0	1,121.0	126.3	152.0	99.0	41.4	14.0	74.0	126.3	152.0	99.0

Data source Swedish National Board of Health and Welfare, 2010. Statistics Sweden, 2010

from ladders, scaffoldings, out of or through building or building structures decrease at older age.

There are some gender differences (based on fall types) among the youngest group of the elderly at the county level, while men and women are still physically active. Overall, older women experience more falls in total than men, but this may vary by category of fall. Interestingly, men are more exposed to falls than women in outdoor environments due to ladder climbing, walking on scaffoldings, falling through buildings or building structures. As men grow older, they are more likely to experience falls on ice and snow. However, there is a decline in rates of falls on ice and snow among older women aged 85 and above at the regional level as they may refrain from outdoor activities. As this happens, a sharp increase in falls from furniture or due to slipping, tripping, and stumbling after age 75 is identified among Swedish older men and women at the county level.

Table 3 shows the proportion of the elderly fallers by location in Sweden counties in 2010. The elderly are more likely to experience falls in the house and in surrounding environments since they spend most of their time indoors or in nearby areas. After, ignoring unspecified locations, elderly residential institutions are the second location where the elderly are vulnerable to falls, followed by streets (which can also be close to home), and then school, other institutions and public administrative areas. Men may tend to have mobility patterns that are more devoted to public spaces than women, this may explain why the elderly men are more likely to fall in public spaces (including athletic and sporting areas, industrial and construction sites, and farming) than streets and roads than women.

Table 3 The number/proportion of elderly experienced fall by location, 2010

Location of fall	Men	Women	Both sex
Housing and immediate environment	5,278	12,197	17,475
	30.2 %	69.8 %	
Residential institution	1,086	2,334	3,420
	31.8 %	68.2 %	
School, institution, public administrative area	422	572	994
	42.5 %	57.5 %	
Sports and athletics area	70	63	133
	52.6 %	47.4 %	
Street	370	827	1,197
	30.9 %	69.1 %	
Trade and service area	76	205	281
	27.0 %	73.0 %	
Industrial and construction	11	4	15
	73.3 %	26.7 %	
Agricultural areas	27	13	40
	67.5 %	32.5 %	
Other specified places	182	337	519
	35.1 %	64.9 %	
Total	5,240	10,179	15,419

Data source Swedish National Board of Health and Welfare, 2010

Trends

The rate of falls among Swedish older population has decreased by 2 % over the past decade at the county level. Figure 1a shows the growth rate of total fall rates from 2001 to 2010 while Table 4 indicates the rate of total falls in 2010, and 2001. Figure 1b compares the growth rate of falls with the growth rate of the elderly population in the same period.

Figure 1b shows that as the number of the elderly fall has increased, the number of the older population increases too. There are four exceptions in Västmanlands, Västerbottens, Norrbottens, and Skånetwo Counties, in which an increase in number of falls was not associated with the proportion of the elderly population. In 2010, the highest rate of falls are witnessed among the elderly living in the Northern counties, despite these counties showing some of the lowest fall growth rates in the same period, which means that their rates are stably high. Even within northern counties, there are some differences. For instance, the Northern counties of Västernorrland, Norrbotten, and Jämtland counties show the largest decrease (Table 4). One of the possible explanations for this trend is related to the difference between the number of inpatient and outpatient records. This means that some injury incidents recorded in outpatient data are not included in inpatient data because of missing external cause codes of the injury. For instance, 6.7 % of the elderly injuries in Västernorrland were recorded without external cause codes in 2010, and therefore were not added to this data. The numbers for Jämtland and Norrbotten are 1.7 and 1.3 % respectively in 2010. This implies that the growth rate of the elderly falls in these counties could

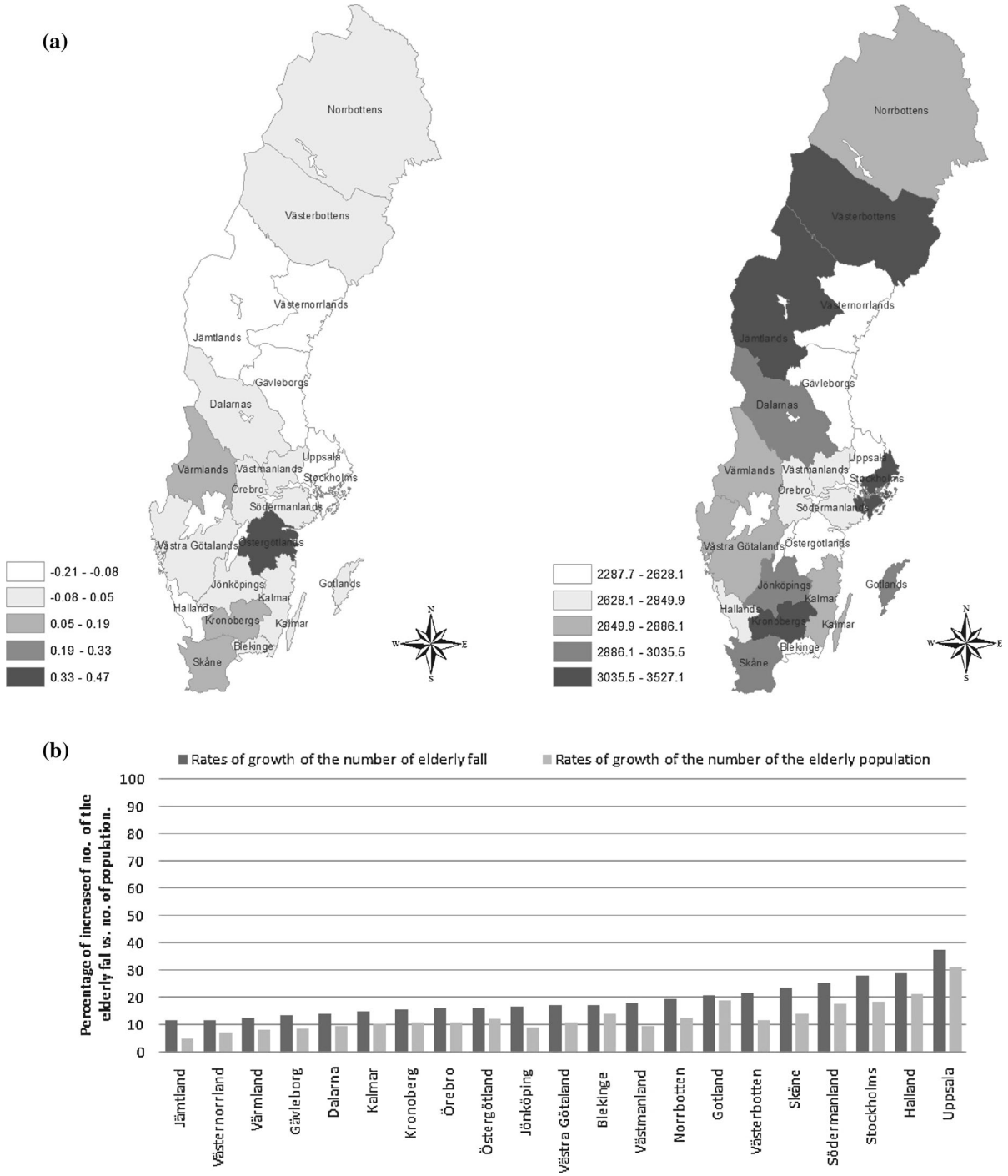

Fig. 1 **a** *The left map* growth rates of total fall (per 100,000 elderly populations) from 2001 to 2010, by county, for both sexes aged 65 years and older. *The right map* the rates of the total fall (per 100,000 elderly populations) in 2010, by county for both sexes aged 65 years and older. *Data source* Swedish National Board of Health and Welfare 2001–2010. Statistics Sweden, 2001–2010. **b** The rates of growth of the number of the elderly population versus number of the elderly fall from 2001 to 2010. *Data source* Swedish National Board of Health and Welfare, 2001–2010. Statistics Sweden, 2001–2010

Table 4 Rates of total fall in 2010 and 2001, by county, for both sexes aged 65 years and older (per 100,000 elderly populations)

Counties	Rates of elderly fall 2001	Rates of elderly fall 2010	Rate of growth of elderly fall, 2001–2010 (%)
Stockholms	3,205.8	2,894.4	−9.7
Uppsala	2,776.3	2,453.3	−11.6
Södermanlands	2,516.0	2,524.5	0.3
Östergötlands	1,678.0	2,437.6	45.3
Jönköpings	2,668.6	2,736.6	2.5
Kronobergs	2,665.2	3,006.9	12.8
Kalmar	2,865.8	2,704.4	−5.6
Gotlands	3,035.0	2,880.5	−5.1
Blekinge	2,349.6	2,194.8	−6.6
Skåne	2,542.1	2,760.4	8.6
Hallands	2,916.6	2,537.6	−13.0
Västra Götalands	2,741.7	2,668.8	−2.7
Värmlands	2,505.2	2,740.7	9.4
Örebro	2,653.5	2,671.3	0.7
Västmanlands	2,474.8	2,518.6	1.8
Dalarnas	2,772.6	2,757.9	−0.5
Gävleborgs	2,779.2	2,473.1	−11.0
Västernorrlands	3,087.1	2,382.5	−22.8
Jämtlands	3,632.8	3,058.8	−15.8
Västerbottens	3,105.0	3,194.2	2.9
Norrbottens	2,767.9	2,664.4	−3.7
Sweden	2,757.3	2,702.8	−2.0

Data source Swedish National Board of Health and Welfare, 2001–2010. Statistics Sweden, 2001–2010

be higher than what Table 4 depicts. Conversely, in Östergötland County in Southern parts of Sweden, fall rates rose by about 45.3 %—this county had one of the lowest fall rates over the last 10 years (namely 2,437.6 compared with the national average 2,702.8 in 2010). This surprisingly rise is partially explained by poor data recording: 46.2 % of all the elderly injuries in Östergötland are missing in 2001 in a category of external causes of the injuries (Jacobsson's interview, 2013). Furthermore, the differences in infrastructure and costs of the elderly care between municipalities should certainly play a role in either minimizing or exacerbating injuries. It is unknown whether the amount and quality of resources provided by municipalities affect the elderly capacity to live in their own homes and consequently, impact on their likelihood to be a victim of fall.

Figure 2 shows also the correlation between the rates of the elderly fall (per 100 older populations) and the minimum yearly temperature.

Regional patterns of elderly falls in Sweden by type

Figure 3 shows elderly fall rates by type of fall for both sexes in 2010 at the county level. Overall, the Northern region of Sweden shows the highest rates of elderly falls on ice/snow and falls caused by slipping, tripping or stumbling. The Eastern parts of Sweden are more associated with falls from ladders, scaffoldings, or

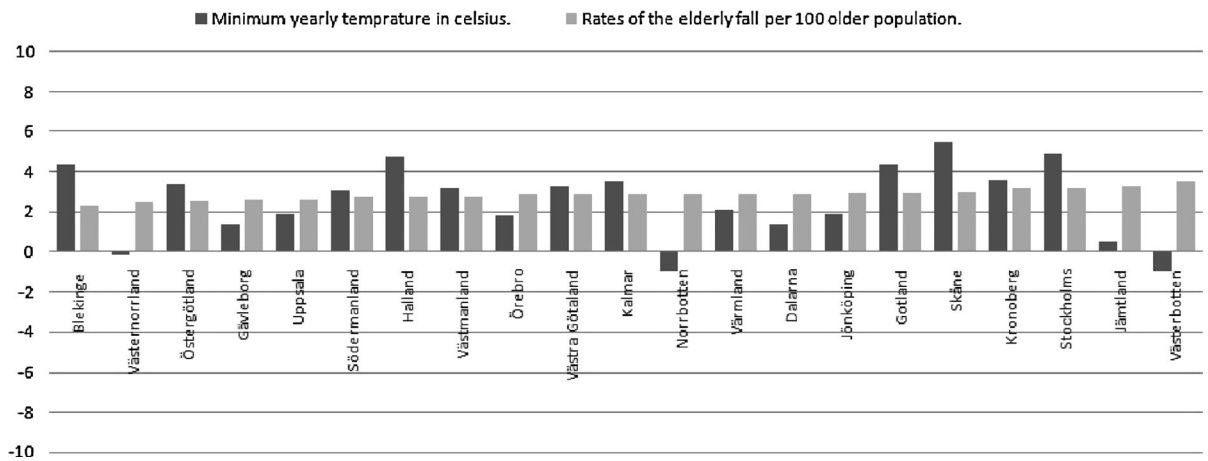

Fig. 2 The plot of the relationship between the rates of the elderly fall per 100 older populations against the minimum yearly temperature of Sweden counties in 2010. *Data source* Statistics Sweden, 2010. Swedish National Board of Health and Welfare, 2010. The Swedish Meteorological and Hydrological Institute, 2010

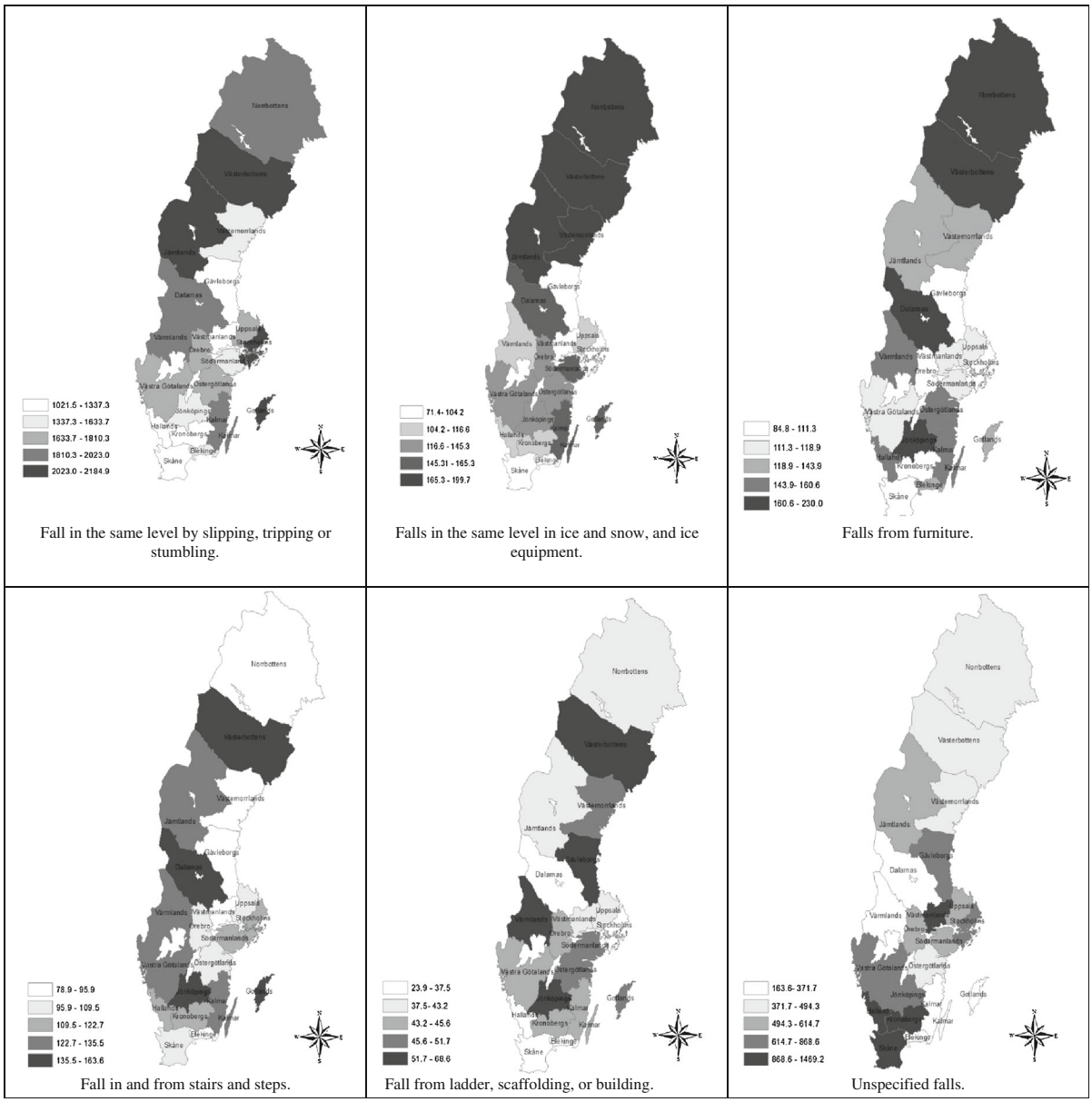

Fig. 3 Quantile maps of fall rates (per 100,000 older populations) of the selected codes associated with the highest share of fall incidents, by county, for both sexes, in 2010. *Data source* Swedish National Board of Health and Welfare 2001–2010. Statistics Sweden, 2001–2010

buildings. Falls from stairs or ladders are more common in the West of the country. Finally, the South hosts counties with the highest rates of unspecified falls.

Figure 4 shows the map of falls at the county level by three location groups: The first one includes falls in the home and home environment, the second group contains falls on the street and the third one shows the rest of the falls. Regardless of the fall location, the fall rates tend to be higher in the Northern part of the country, which decrease further South (exceptions are Stockholm and Gotland). Västerbotten, Dalarna, Jönköping, and Stockholm show high rates of indoor falls and within the home environment, while Västerbotten, Örebro, Stockholm, and Östergotland represent the highest rate of falls on the street. It is also relevant to point out that counties with the highest rates of indoor

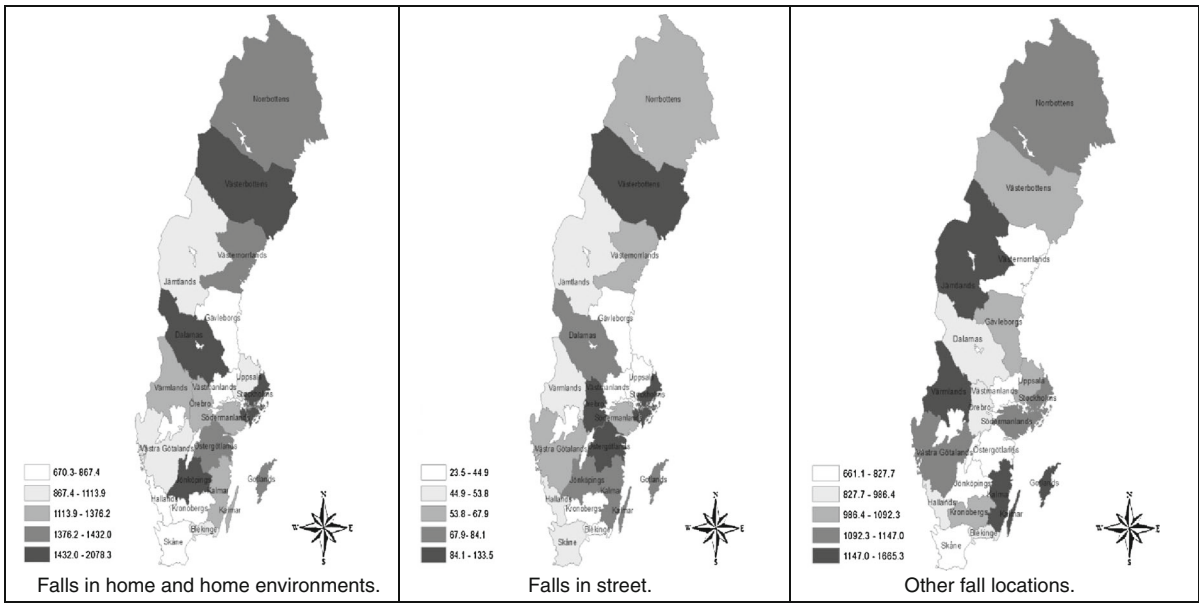

Fig. 4 Quantile maps of fall rates (per 100,000 older populations) by location, by county, for both sexes, in 2010. *Data source* Swedish National Board of Health and Welfare, 2001–2010. Statistics Sweden, 2001–2010

falls also exhibit high outdoor fall rates (e.g., fall in the street).

The p values of The Fisher Exact Test are presented in Table 5, and the results of the Spearman's Rank are presented in Table 6. The results indicate an association between the counties with colder winters and rates of falls from the furniture among the elderly (FET[4]: $p = 0.063$ and $p = 0.023$, SRC[5]: rho $= -0.631$, $p = 0.002$). Counties with cold winters also show a strong association between fall rates on ice or snow and the use of ice skate/board equipment among the 85+ age group as well as elderly women (FET: $p = 0.023$, $p = 0.023$, SRC: women; rho $= -0.553$, $p = 0.009$, aged 85+; rho $= -0.671$, $p = 0.001$). Moreover, there is a significant relationship between the rate of falls from furniture among older groups and the temperature of the counties that experience cold winters (aged 75–79, FET: $p = 0.023$, SRC; rho $= -0.589$, $p = 0.005$), and (aged 80–84, FET: $p = 0.002$, SRC; rho $= -0.621$, $p = 0.003$). A similar pattern is found when fall rates are associated with minimum yearly temperature in winter. There is a significant association between the minimum yearly temperature of counties and rates of falls on ice and snow and the connection to ice skate/board equipment for elderly men and women as well as all age groups except older adults aged 80–84($p = 0.063$ for all indicated variables in FET) and (SRC: aged 65–69: rho $= -0.471$, $p = 0.031$/aged 70–75: rho $= -0.585$, $p = 0.005$/aged 75–79: rho $= -0.474$, $p = 0.03$/aged 85+: rho $= -0.710$, $p = 0.000$/women: rho $= -0.668$, $p = 0.001$/men: rho $= -0.598$, $p = 0.004$). This association is strongly significant for people age 85 years and older at level $p = 0.007$ and $p = 0.000$ for The Fisher Test and Spearman Rank Correlation respectively. As expected, The Fisher Exact Test confirms the association between the rate of falls caused by slipping, tripping, or stumbling among the elderly aged 85 years or older and the minimum yearly temperature in Swedish counties (FET: $p = 0.063$, SRC: rho $= -0.457$, $p = 0.036$). The association between the minimum yearly temperature and the rates of elderly falls from ladders, scaffoldings, or buildings is significant at 10 % for older women (FET: $p = 0.063$, SRC: rho $= -0.480$, $p = 0.028$) but interestingly, not for men.

No association is found between the housing type (the share of single family housing vs. multifamily housing available in Swedish counties) and the rates of falls among all fall types as well as fall age groups. The

[4] Fisher Exact Test.

[5] Spearman's Rank Correlation.

Table 5 The Fisher Exact Test (p value)—falls rate versus age, gender, housing type and temperature

Fall rates group	Age/gender group	Housing type	The coldest temperature in winter	The minimum yearly temperature
Fall in the same level in connection to ice and ice equipment	Age 65–69	(1.00, 0.575)	(0.198, 0.135)	(0.086, 0.063)
	Age 70–74	(0.387, 0.245)	(0.198, 0.135)	(0.086, 0.063)
	Age 75–79	(0.387, 0.245)	(0.198, 0.135)	(0.086, 0.063)
	Age 80–84	(0.670, 0.425)	(0.198, 0.135)	(0.395, 0.260)
	Age 85+	(1.00, 0.575)	(0.03, 0.023)	(0.009, 0.007)
	Men	(0.387, 0.245)	(0.670, 0.410)	(0.086, 0.063)
	Women	(0.670, 0.425)	(0.03, 0.023)	(0.086, 0.063)
	Total	(0.198, 0.135)	(0.198, 0.135)	(0.086, 0.063)
Fall in the same level by slipping, tripping or stumbling.	Age 65–69	(1.00, 0.575)	(0.670, 0.410)	(0.395, 0.260)
	Age 70–74	(1.00, 0.575)	(0.670, 0.410)	(1.00, 0.590)
	Age 75–79	(0.387, 0.245)	(0.670, 0.410)	(0.395, 0.260)
	Age 80–84	(1.00, 0.575)	(0.670, 0.410)	(0.395, 0.260)
	Age 85+	(0.670, 0.425)	(0.670, 0.410)	(0.086, 0.063)
	Men	(1.00, 0.575)	(0.670, 0.410)	(1.00, 0.590)
	Women	(1.00, 0.575)	(1.00, 0.590)	(0.395, 0.260)
	Total	(1.00, 0.590)	(1.00, 0.590)	(0.670, 0.410)
Falls from furniture	Age 65–69	(1.00, 0.623)	(0.387, 0.245)	(0.670, 0.425)
	Age 70–74	(0.396, 0.284)	(0.387, 0.245)	(0.670, 0.420)
	Age 75–79	(0.670, 0.425)	(0.03, 0.023)	(0.395, 0.260)
	Age 80–84	(1.00, 0.575)	(0.002, 0.002)	(0.395, 0.260)
	Age 85+	(1.00, 0.575)	(0.135, 0.198)	(0.395, 0.260)
	Men	(0.670, 0.425)	(0.086, 0.063)	(0.198, 0.135)
	Women	(1.00, 0.575)	(0.03, 0.023)	(1.00, 0.590)
	Total	(1.00, 0.575)	(0.063, 0.023)	(0.395, 0.260)
Fall in and from stairs and steps	Age 65–69	(0.387, 0.245)	(1.00, 0.590)	(0.670, 0.410)
	Age 70–74	(0.387, 0.245)	(0.670, 0.410)	(0.670, 0.410)
	Age 75–79	(0.670, 0.425)	(0.670, 0.410)	(0.395, 0.260)
	Age 80–84	(0.387, 0.245)	(0.670, 0.410)	(1.00, 0.590)
	Age 85+	(0.670, 0.425)	(0.670, 0.410)	(1.00, 0.590)
	Men	(1.00, 0.575)	(0.198, 0.135)	(1.00, 0.590)
	Women	(0.670, 0.425)	(0.395, 0.260)	(0.198, 0.135)
	Total	(0.395, 0.260)	(1.000, 0.590)	(0.670, 0.410)
Fall from ladder, scaffolding, or building	Age 65–69	(0.660, 0.377)	(1.00, 0.575)	(1.00, 0.575)
	Age 70–74	(0.387, 0.245)	(0.670, 0.410)	(0.395, 0.260)
	Age 75–79	(0.08, 0.056)	(1.00, 0.570)	(0.395, 0.260)
	Age 80–84	(0.198, 0.142)	(0.670, 0.410)	(0.395, 0.260)
	Age 85+	(0.387, 0.245)	(1.00, 0.590)	(0.670, 0.410)
	Men	(1.00, 0.575)	(0.670, 0.410)	(0.395, 0.260)
	Women	(0.387, 0.245)	(0.670, 0.410)	(0.086, 0.063)
	Total	(1.00, 0.575)	(0.395, 0.260)	(0.198, 0.135)

Table 5 continued

Fall rates group	Age/gender group	Housing type	The coldest temperature in winter	The minimum yearly temperature
Total	Age 65–69	(1.00, 0.575)	(0.670, 0.410)	(1.00, 0.590)
	Age 70–74	(0.387, 0.245)	(0.670, 0.410)	(0.395, 0.260)
	Age 75–79	(1.00, 0.575)	(1.00, 0.590)	(1.00, 0.590)
	Age 80–84	(0.387, 0.245)	(1.00, 0.590)	(0.670, 0.410)
	Age 85+	(0.198, 0.142)	(0.395, 0.260)	(0.670, 0.410)
	Men	(0.387, 0.245)	(1.00, 0.590)	(1.00, 0.590)
	Women	(0.670, 0.425)	(1.00, 0.590)	(1.00, 0.590)
	Total	(1.000, 0.590)	(0.670, 0.410)	(1.000, 0.590)

Significant at 10 % level, significant at 5 % level and significant at 1 % level

Data source Swedish National Board of Health and Welfare, 2010, The Swedish Meteorological and Hydrological Institute, 2010, Statistics Sweden, 2010

only exception relates to falls from ladders, scaffoldings or buildings for people aged 75–79 in single family houses ($p = 0.056$).

All significant associations from The Fisher Exact Test are also significant according to the Spearman's Rank except for the association between the number of the single family housing and fall from ladders, scaffoldings or buildings for people aged 75–79 (Table 6).

Discussion of the results

Slipping, tripping, and stumbling accounts for 57 % of the elderly falls in Sweden counties. It may be reasoned that these activities are part of the common daily routines and are necessary for independent living of an individual. The fall injuries mostly happen when the elderly are walking, going to bed or toilet, cooking, cleaning and shopping. Similar findings were also found elsewhere (Berg et al. 1997; Reinsch et al. 1993). As it could be expected, homes and the immediate environments are the most common places where elderly Swedes fall (53 % of all fall injuries) as older people spend most of their time at home and nearby environments.

Elderly Swedish women are 1.6 times more likely than older men to experience falls at the county level. However, this gender-based difference in falls fades as men and women get older. Prior studies also suggest that older women fall more frequently than men (Griffin et al. 1992; Ytterstad 1999; Stevens and Sogolow 2005; Campbell et al. 1981; Prudham and Grimley-Evans 1981). This might occur due to the fact that women, particularly after menopause, develop a more fragile body that is more vulnerable to falls. However, the likelihood varies by gender and specific types of falls. Older men tend to fall outdoors more often than indoors, such as while ice skating, skiing, roller skating, ladder climbing, walking on scaffoldings, or by falling from a building structure and trees, such as farms, industrial areas, and athletic sport facilities at the regional level. Conversely, female senior citizens are more prone to falls in the house, streets, school, and service areas than men at the county level. In the case of Sweden, there were indications that as individuals get older, they experience fewer outdoor falls due to their poor health conditions and inactive lifestyles (Oswald and Wahl 2005; Rosenbloom 2000). For instance, Swedish senior citizens are less likely to experience falls from ladders, scaffoldings and buildings as they get older.

Counties in Northern Sweden tend to have the highest rate of falls. Long cold winters in the Northern counties associated with many snowy months; increase the risk of falling among the elderly than is the case in Southern parts of the country. Researchers concur that freezing temperatures lead to increased risks of slipping (Rális 1981; Manning et al. 1982; Rális 1986). Limited access to sunlight, especially in winter, may result in poor visual acuity and inadequate levels of vitamin D, which are the potential risk factors for falls (Bergstralh et al. 1990). The high risk of falls might also be associated with inadequate access to basic services such as grocery stores as well as the number of paved streets. Most of these activities are done by car but some are done on foot. If done on foot, the risk of falls rises.

Table 6 The Spearman (rho, p value)—Falls rate versus age, gender, housing type and temperature

Fall rates group	Age/gender group	Housing type	The coldest temperature in winter	The minimum yearly temperature
Fall in the same level in connection to ice and ice equipment	Age 65–69			(−0.471, 0.031)
	Age 70–74			(−0.585, 0.005)
	Age 75–79			(−0.474, 0.030)
	Age 80–84			(−0.598, 0.004)
	Age 85+		(−0.676, 0.001)	(−0.710, 0.000)
	Men			(−0.598, 0.004)
	Women		(−0.553, 0.009)	(−0.668, 0.001)
	Total		(−0.563, 0.008)	(−0.665, 0.001)
Fall in the same level by slipping, tripping or stumbling.	Age 65–69			
	Age 70–74			
	Age 75–79			
	Age 80–84			
	Age 85+			(−0.457, 0.036)
	Men			
	Women			
Falls from furniture	Age 65–69			
	Age 70–74			
	Age 75–79		(−0.589, 0.005)	
	Age 80–84		(−0.621, 0.003)	
	Age 85+			
	Men		(−0.631, 0.002)	
	Women		(−0.574, 0.007)	
	Total		(−0.631, 0.002)	
Fall from ladder, scaffolding, or building	Age 65–69	No association		
	Age 70–74			
	Age 75–79			
	Age 80–84			
	Age 85+			
	Men			
	Women			(−0.480, 0.028)

Significant at 10 % level, significant at 5 % level and significant at 1 % level

Data source Swedish National Board of Health and Welfare, 2010, The Swedish Meteorological and Hydrological Institute, 2010, Statistics Sweden, 2010

Although between 80 and 86 % of the population living in various counties can access the nearest grocery stores by car in less than 5 min, there are 4–6 % of the population who need to drive for 10–30 min to the nearest grocery store (average percentage for Sweden is 1.6). Whereas in Sweden there is an average of only 24 % unpaved county streets, in some of the Northern counties, the percentage of unpaved streets can reach 58 %.

Geographical isolation may also play a role in increasing the risk of falls among the elderly. The island of Gotland appears as a county with relatively high rates of falls on ice and snow, falls due to slipping and tripping, and falls from stairs and steps. In Gotland, almost 21 % of the population drives between 5 and 10 min to access the nearest grocery store, which is about twice the time the other residents drive in the Northern counties.

Fall-related fractures are associated with reduction in yearly temperature. However, there are a few exceptions in the central and Southern parts of the country (where the low temperatures and snow last for a short time). These exceptions include counties such as Kalmar, Södermanland and Gotland. Counties associated with the highest rates of falls from furniture are evenly scattered in Sweden and include Norrbotten, Västerbotten, Dalarna, and Jönköping).

The results of The Fisher Exact Test show that the rates of falls from furniture are associated with the coldest winter temperature in the counties. The elderly stay indoors for long durations, which explains the prevalence of indoor falls. Regarding the age group and gender, older adults aged 75–84 are more likely to fall from furniture in the cold winter counties. Older people in this age group are not as active as the elderly aged 65–75, but are less passive than those aged 85 and older in managing their daily routine activities. Thus, those adults aged 75–84 may want to have some control of their daily lives, which may result in more indoor falls. The presence of a strong association between the rate of falls on ice and snow and the coldest winter temperature for older women and those aged 85 and beyond has implications. Their fragile bones, coupled with a decline in their circulatory systems due to cold temperature and engaging in risky activities makes older people (particularly the oldest) more prone falls. Some studies indicate that freezing temperature leads to increase risks of slipping (Rális 1981; Manning et al. 1982; Rális 1986).

The fall rate on ice and snow in relation to ice skate/boards tends to be higher in counties with the higher minimum yearly temperature (for both sexes, and all age groups except the elderly aged 80–84). This may be because in snowy seasons of the year, in some counties, the temperature is mild enough to allow outdoor activities for the elderly. Thus, outdoor activities such as walking, jogging or gardening are more frequent in these areas, and consequently, may result in more falls among the elderly. The cold temperature mostly increases the likelihood of falls among the oldest adults (age 85 years and older). According to Lin and Xiraxagar (2006), a significant increase in the rate of fall-related fractures is associated with lower temperature. This finding is also similar to studies showing seasonal trends in fracture rates (Levy et al. 1998; Mirchandani et al. 2005).

Older women are more likely to fall from ladders in counties associated with higher minimum yearly temperature. This may also imply a higher level of engagement in outdoor activities in counties with milder weather. However, ladder climbing in old age is mostly associated with men as opposed to women at the county level. Elderly women may not be as agile as their male peers in undertaking risky activities such as ladder climbing. Moreover, due to their physiology, they tend to have less bone density. These aspects imply that elderly women are more at risk of falling from ladders. A strong association is also found between the rate of falls caused by slipping, tripping or stumbling, and the minimum yearly temperature of the counties for people aged 85 and older. In confirmation of the previously stated hypothesis, there is an association between the rate of elderly falls and seasonal variations in temperature in Sweden.

The presence of the relationship between the type of housing and the rates of falls is confirmed only for falls from ladders, scaffoldings and buildings for the 75–79 age group at the county level. Although chronological age is not perfectly related to functional age, those in the 65–74 age group are assumed to be 'young old adults'. After eighty, the elderly may be more fearful of engaging in risky activities as they may encounter more difficulties in coping with their routine daily lives. Thus, the 75–79 age group depicts a delicate phase among the elderly, especially since they may still feel healthy and capable despite the fact that their bodies might not to be agile. However, no association has been found between the rates of fall from ladders, scaffolding or building for the elderly aged 75–79 and the number of single family housing based on Spearman's Rank Correlation. This may be explained by the differences between categorizing and ranking process respectively in The Fisher Test and Spearman. In The Fisher Test, all the variables are divided into three groups (Lowe, medium, high) based on the value of each in compare to the median value of the variables. Thus

Final considerations

The study examines the nature, trends, and the patterns of elderly falls at a regional level in Sweden. In this study, the relationship between patterns of falls by county is investigated by looking at the population's

gender, age and variations in temperature across the counties.

Although the analysis shows that fall rates among the elderly has been decreasing between 2001 and 2010 across Sweden, the pattern of decline in fall rates is not geographically homogenous. Interestingly, a higher decline rate from 2001 to 2010 can be noted for most of the Northern counties, with the highest decline in fall rates in 2010. Slipping, tripping, and stumbling are the most common causes of the elderly fall injuries at the county level. This study reveals that elderly men and women differ in their types of falls, although elderly women fall more frequently than men at county level. Further, older men are more exposed to falls since they engage in risky activities such as ice skating, skiing, and ladder climbing. However, the causes of falls may vary among the different elderly age groups. For instance, the older elderly group is more prone to falls caused by routine daily activity such as tripping, and stumbling, falls from stairs, steps and furniture, while the younger elderly group is more likely to fall due to higher activity levels such as falls in connection with the use of ice skate equipment.

There are substantial geographic differences in the distribution pattern of fall rate by types in Sweden. Unsurprisingly, the Northern counties show the highest rate of falls caused by ice and snow and snow equipment. But the Northern parts of Sweden tend to have higher fall rates caused by slipping, tripping, or stumbling, and fall from furniture. The East represents more rates of falls from stairs and steps, while the West accounts for falls from ladders, scaffoldings, or buildings. Finally, Southern Sweden is recognized for the highest rates of unspecified falls.

Further, the association between the rate of some fall types and the coldest winter temperature and minimum yearly temperature provides evidence of the impact of seasonal variations in elderly falls in Sweden counties. A decline in temperature in the coldest months of the year may increase the risk of indoor falls, while outdoor falls may increase in warmer months at the regional level. Additionally, the type of housing available in Swedish counties may not affect the rates of falls among the elderly at the county level. However, the results evidence only one category, namely single family housing and its effect on fall rates from ladders, scaffoldings, and buildings among the 75–79 age group.

What can be learned from this methodological approach? The method can be used as component of research on geographical contextual effects. For instance, researchers can study whether or not the social and/or physical characteristics of places in which people live are factors of risk but also protection to individuals. Where geographic variation is small, group level factors related to geography are less likely to explain individual level variation in injuries. However, if quantifiable geographic variation exists then such variation can be explained by the ecological nature of injuries fall.

The study makes a contribution to the geographical analysis of elderly fall in a Scandinavian country and, as any other ecological analysis, show evidence of relationships that are limited to group level characteristics, in this case, by counties. These regions are not homogenous and differences in population density and basic infrastructure are bound to affect these rates of fall. Differences in socio-economic conditions of the elderly population and community health services in each county can certainly help in explaining variations in fall rates among the elderly. Municipalities and hospitals vary in the services they may provide, which can potentially affect the elderly patients' health conditions and indirectly, the risk of falls. Good health is also associated with satisfactory standards of living. Data permitting, the socio-economic condition during old age is a fundamental factor to be considered when assessing patterns of elderly falls. Future research should assess the relationship between elderly lifestyles (use and perception of local space: buildings and the overall urban landscape) and associated risk exposure to falls. In this current study, it is assumed that they were the same both within and across counties.

The analysis also suffers from data limitations. For instance, since in-patient data includes more serious injuries resulted in hospitalization; many other injuries that resulted only in emergency departments are unreported in this database and are missing in the analysis. Further, statistics related to the number of rooms of the apartments or apartments available in each county have not been completed yet by Sweden Statistics (SCB) and the data does not cover the entire number of available apartments. Although the presence of discrepancies in the inpatient and outpatient injury records may help explain why some counties such as Östergotland, and Västernorrland show high or low rate of growth of elderly falls, respectively, this is also indicative of other data quality issues and

limitations of recording of falls among the elderly population, particularly in these counties. Further, the age-standardized rates were not calculated due to the lack of the data on population standard of each county. Instead, we rely only on rates of fall per 100,000 populations. Since age-standardized rates is calculated based on the population structure of each county including all age groups, the results would be more robust.

This study, despite the above mentioned limitations, contributes to a better understanding of county patterns in elderly fall rates in a Scandinavian county. The study suggests the elderly housing environments as the most risky areas for the elderly to fall. In order to avoid these injuries, more attentions should be paid to home safety assessments and modifications by planners and decision makers. Regarding indoor environments, previous literature shows that some sections of the house heighten the risk of falling, such as the kitchen and bathroom. There is also need to determine which physical characteristics of housing units (including interior design and types of furniture) influence the rates of elderly falls. Equally important is the surrounding environments, outdoors, especially places where the elderly spend most of their time.

Working with large areas in geographic analysis may not be useful enough to capture the spatial differences. Thus, future researches is needed to examine whether injury incidents are more influenced by highly localized context (e.g. icy road path conditions outside of a senior's dwelling) compared to the other forms of health variations such as infectious diseases that might be influenced by weather patterns at larger scales.

In this study, slipping, tripping, and snubbing as well presence of ice and snow are recognized as the main causes of the elderly fall in Sweden counties, and particularly among the northern counties. Future research is needed to investigate the casual mechanism of these types of fall in particular. Further, a variety of prevention strategies could be applied by local authorities to reduce the risk of fall. For instance: using assistive devices and safety equipment, keeping walking areas clear of ice and snow, health education programs, and running a home food delivery services for the older population specially during the winters, providing proper illumination for doorways, steps, porches, and walkways in dark months. Moreover, winter street and sidewalk maintenance should be high priorities for the local authorities. Particular attention must be given to improve and maintain the quality of the pavement of the streets and pedestrian path in winters by the local authorities, and planners. Regarding the indoor environments, residential floor warming system could be used as a preventive measure to avoid the fall injuries caused by slipping as a result of wearing a warmer, ticker socks in cold weather. Light switches must be in hand and located in the right place of each part of the housing to have illumination in dark winter.

The study shows that older population differs in the type of falls they experience based on the gender, and age differences. This could be the areas of concern for policy makers, planners, and health care services when designing and assigning fall preventive measures.

Future studies should further explore reasons of why certain types of elderly falls are more common in some counties than in others. This study points out directions for further research in the local level patterns of elderly fall, especially in relation to housing (indoors and outdoors).

Findings put forward here may facilitate the planning and implementation of policies directed towards enhancing the safety of the elderly in Sweden, especially those related to housing needs, provision and accessibility of healthcare services in areas that face differentiated climate challenges.

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