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The regional ecology of elderly falls in Sweden

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Abstract The study assesses exploratory the geography of the elderly fall in Sweden in relation to the ecology of the socio-demographic characteristics of the Swedes older population. Kendall Test is used to measure the association between elderly fall rates and demographic, socio-economic characteristics of the population, costs of elderly care and accessibility measures at county level. Results show a number of significant associations: high rates of the elderly fall are associated with high cost of the elderly care but also low rate of elderly fall and good accessibility to basic services (e.g., grocery store, health care and cash machines). The articles finalizes with reflections of the results and suggestions for future research.

Keywords Ecology of fall · Elderly fall · Socio demographic variations · Geography of fall

Introduction

Injuries as a result of falling are considered a major public health problem, particularly among the elderly.[1] When a person reaches this age group, a simple fall may result in serious consequences, such as fractures, brain injury, and in severe cases, death. Studies suggest the presence of geographical variations for falls among different areas of one geographical unit (Dhanwal et al. 2011). As social, spatial, demographic, and environmental factors may vary from one location to another, these variations may result in geographic differences of the elderly fall (e.g., Cauley 2011; Yiannakoulias et al. 2003).

In Sweden, where a substantial portion (19 %) of the population is elderly, injuries sustained due to falls are most commonly experienced by the older population. As many as 57 % of the Swedish elderly experienced falls caused by slipping, tripping, and stumbling in 2010, particularly in some of the more northern counties. However, little is known about the distribution of elderly falls over space, and whether it relates to the ecology of the population (demography, socio-economic factors by county), costs of elderly care, and accessibility measures at the county level. Furthermore, in recent decades, researchers have explored the links between social, spatial, and environmental factors and health and healthcare variations rather than focusing only on the impact of medication on health variations (Bailey et al. 2006).

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

This article makes a contribution to this recent body of research by examining the ecology of the rate of elderly falls. This article adopts Haining's (2012:143) definition of ecological analysis. The author defines it as "the analysis of aggregated data in terms of groups of individuals. Many types of aggregation are possible, such as social class, socio-economic status or the employment status of individuals. Geographical area is one important type of data aggregation (grouping individuals by their geographical, often residential, location) and may be undertaken on a number of scales". In this study, the scale is regional and the data is at the county level.

The research discussed henceforth draws upon an earlier study by Authors (Bamzar and Ceccato 2014), which showed that counties that experience long, cold winters tend to show higher rates of indoor falls than those with warmer temperatures throughout the year. In this first study, the population's characteristics (demography, socio-economic conditions), costs of elderly care, and accessibility measures were not taken into account.

This research assesses the geography of elderly falls by county in Sweden, and associates it with a number of characteristics of the Swedes' older population, services, and accessibility. The article concludes with reflections on the results and suggestions for future research.

The elderly represent a growing part of the Swedish population (19 %), and by 2030 this amount will grow to reach approximately 30 %. Most of the Swedish elderly are in good health and live in their own home. Furthermore, the geographical length of Sweden, from north to south, is its most notable geographical feature, which causes a variety in climate across the country. For instance, the north of Sweden endures 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).

Theoretical background and hypotheses

Hippocrates was the first person to point out that space and health are related in some aspects (Chris 2009). Furthermore, in the last two decades, many studies confirm the relationship between place and health variations. Here, place is defined as an atmosphere containing both individual and environmental factors that may influence disease rates and health indicators. For instance, Smoyer (1998) suggests the association between the temporal and socio-economic factors and heat-related illnesses. Moreover, the level of accessibility to dental services is linked to the rates of dental related diseases (Bradley et al. 1978). Johnel et al. (1992) suggest the existence of geographic differences in elderly falls across continents. This variation in space refers to the spatial variations of the fall risk factors (Yiannakoulias et al. 2003).

In essence, a fall is a product of complex interaction between multi-dimensional factors (Chan et al. 2011; Wågert et al. 2009). Most of the research on factors involved in falls suggests two dominant areas of concern: individual attributes (intrinsic factors), (Prudham and Grimley-Evans 1981; Neutel et al. 1996; Campbell et al. 1981; O'Loughlin et al. 1993; Wild et al. 1981) and individual's environments (extrinsic factors), (Wild et al. 1981).

Another point of view in studies of fall related injuries looks at the characteristics of both individual and environmental levels which might be the underlying causes of the presence of intrinsic and extrinsic factors. These underlying causes may vary by place. The relationship between place and fall variations has been discussed by geographers (Jones and Moon 1993; Kearns 1993; Kearns and Joseph 1993; Macintyre et al. 1993). Kearns (1993) suggests that geographers should examine the importance of place (considered as both individual and environmental phenomenon) in health and health care variations. Studies show that both people and place make differences in health variations. Different parts of the city, for instance, imply in different risks of fall. Some areas are better served by basic services (short distances to walk) and can be classified as 'elderly friendly', while in others, the elderly face longer distances to basic services, imposing greater risks of fall. This risk is of course associated with the environments the elderly is exposed to, both indoors (layout of apartments, stairs, etc.) and outdoors (pathways, illumination, etc.). On top of these multi scale factors, there might be institutional differences between places that determine, for instance, the quality of services offered to the elderly and that, indirectly, may also affect the statistics of elderly fall.

The multi-dimensions of the fall risk factors and their relation to place is shown in Fig. 1.

In Europe, Scandinavian countries show the highest rates of hip fractures (Falch et al. 1993; Bjorgul and

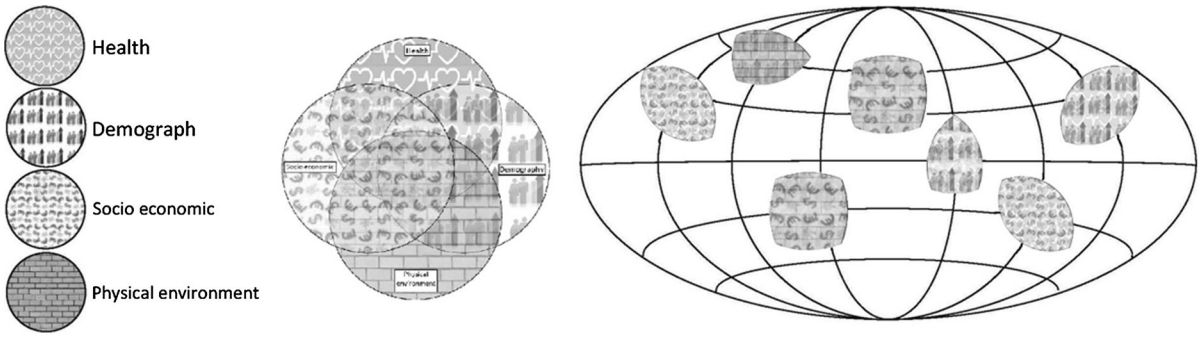


Fig. 1 The interaction between multi dimensional fall risk factors in relation to the place

Reikeras 2007; Finsen et al. 2004). Dhanwal et al. (2011) found that Caucasians living in Scandinavia were more likely to experience hip fractures as a result of falls. This ethnic and geographic variation may be explained by differences in genetic factors, lifestyle, behavioral, and environmental characteristics (Dhanwal et al. 2010). The relationship between fall incidents and ethnical variations has been reported in a number of studies (Cauley 2011; Megyesi et al. 2011; Jacobsen et al. 1992; Penrod et al. 2008; Graham et al. 2008; Nguyen-Oghalai et al. 2009; Dhanwal et al. 2011). The income of the individual may be another important factor suggested by scholars as an implication for fall-related injuries (Kannus et al. 1999; Tinetti et al. 1988; Galizia et al. 2008; Luukinen et al. 1996). Trujillo et al. (2011) suggest that having a higher income may contribute to better socio-economic conditions such as a healthier diet, and better access to basic social services. Furthermore, lower income is linked to a higher risk of fall (Trujillo et al. 2011; Tinetti et al. 1988; Galizia et al. 2008; Luukinen et al. 1996).

Scholars also show that variations in the health of the elderly are connected to marital status (Van Rossum et al. 2000; Haan et al. 1987; Lopata 1982). Cakar et al. (2011) found that being married is associated with lower rates of fall amongst the older Turkish population, as well as with better social and physical functioning. In a Swedish study, a higher risk of hip fracture was noted profusely among unmarried older men and women (Hokby et al. 2003). Overall, being single in one's older age may be associated with weaker social and physical activities, as well as poor nutrition, and higher levels of medication. These factors, together with lower bone density, may influence the likelihood of the elderly fall.

The place where the older population lives may also play a role in the likelihood of fall. Studies suggest that elderly fall incidents are more common among senior citizens living in institutional and special housing (Sattin et al. 1990; Jäntti et al. 1993). For instance, Rubenstein and Josephson (2002) found that as much as 40 % of the older population who live in institutional housing experience falls. For the older population living in community dwellings, this amount is 30 %. The difference between the amount of elderly fall incidents living in special housing and community dwellings might be explained by the higher number of fragile, older institutional residents, as well as higher medication use. However, there is a lack of enough research on whether the difference in elderly fall incidents may link to the differences in physical environments experienced by the older population.

As the elderly age, the importance of the presence of health and social services will increase (Kehusmaa et al. 2012). Adequate access to healthcare services contributes to health variations. Municipalities are one of the sectors responsible for providing health and social services for individuals at the local and regional level. Studies on elderly care shows the associations between social and support care, and healthier life spans (Andersen 2008; Landi et al. 2001; Sandberg et al. 2012).

There have been noticeable reports by older adults with regards to having difficulty accessing numerous social services such as shops, banks, and hospitals (Burnett 2005). Accessibility is defined as an easy movement between two destinations in terms of distance, cost, and attractiveness (Giuliano et al. 2003).

Aging is always associated with a decrease in both functionality and mobility; therefore, accessible

environments contribute to a decline in the prevalence of falls and enhance the quality of life. Although the presence of online shopping and telecommunications may help the elderly to avoid going out, in most cases, providing daily needs requires a journey to access these services. The length of time, distance, and the cost required to reach these services are critical indicators of accessibility. Shopping for groceries is known as one of the most risky activities for the elderly in relation to falls (Bleijlevens et al. 2010).

Until now, only a few studies have examined the associations between the rates of elderly fall and the implicated socio-economic/demographic factors in Sweden. The results of a cross-sectional study on Stockholm's elderly population showed an association between the rates of fall-related fractures and marital status, foreign born elderly, low economic and social status (Reimers and Laflamme 2007). Hokby et al. (2003) also suggest that unmarried older people living in Stockholm are more likely to experience hip fractures. However, no study has investigated the relationship between elderly fall rate and the socio-economic, demographic status, or accessibility measures to basic services at county level. The previous study by Bamzar and Ceccato (2014) explores, for instance, the impact of temporal pattern on elderly fall resulted in hospitalization at the county level.

Internationally, previous studies show that demographic and socio-economic characteristics affect the prevalence of the elderly fall (Andersen 2008; Cakar et al. 2011; Cauley 2011; Dhanwal et al. 2011; Galizia et al. 2008; Graham et al. 2008; Haan et al. 1987; Hokby et al. 2003; Jacobsen et al. 1992; Kannus et al. 1999; Landi et al. 2001; Lopata 1982; Luukinen et al. 1996; Megyesi et al. 2011; Nguyen-Oghalai et al. 2009; Penrod et al. 2008; Reimers and Laflamme 2007; Sandberg et al. 2012; Tinetti et al. 1988; Trujillo et al. 2011; Van Rossum et al. 2000). Based on this literature, it is suggested that *counties that have higher rates of falls are expected to be associated with one or more of these factors: lower proportion of non-Swedes, greater proportion of non-active population, larger share of low income earners, and single individuals.*

Drawing on previous studies by Rubenstein and Josephson (2002), Sattin et al. (1990), and Jäntti et al. (1993), it is hypothesized that *counties with a higher proportion of elderly individuals living in special housing are more likely to experience falls.*

Similarly, *counties with higher costs for elderly care are correlated with counties with lower rates of seniors fall* (Andersen 2008; Kehusmaa et al. 2012; Landi et al. 2001; Sandberg et al. 2012).

Burnett (2005), Bleijlevens et al. (2010), and Giuliano et al. (2003) related accessibility to services with elderly fall. In Sweden, it is suggested that: *The lower number of elderly falls, the higher number of paved streets at county level. Also, counties that show lower proportions of elderly individuals with shorter distances to basic services (grocery stores, ATM, health care center, and post office), tend to have lower fall rates.*

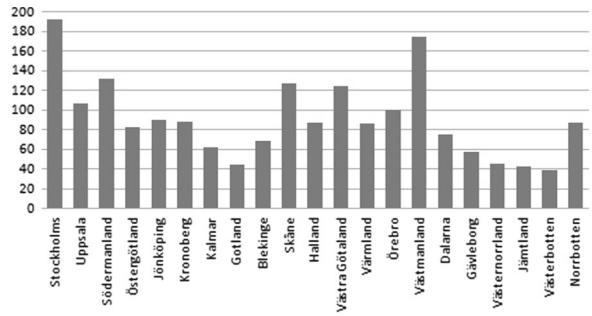
The article is explorative in nature. A detailed geographical analysis based on an integrated causality model was not carried out because of the data limitations. The selection of factors to be tested against elderly fall was driven by both the existent literature (often pointing to different types of factors—see hypotheses) and availability of data at county level. Data permitting, a more coherent conceptual framework would be desirable in future research.

Study area

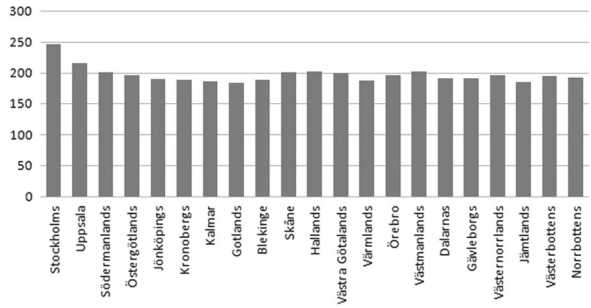
The study area constitutes twenty-one Swedish counties. The rate of growth of the older population has been higher than the rate of growth of the total population from 2001 to 2010 (Bamzar and Ceccato 2014). The Uppsala, Halland, and Gotland counties respectively had the highest elderly population growth rate from 2001 to 2010. However, the older population is mostly concentrated in the South (Stockholm, Västra Götlands, Skåne, and Östergötlands).

As shown in Fig. 2, there are variations in the socio-demographic characteristics of the elderly population by county. Overall, the elderly population of each county of Sweden has increased in both number and percentage from 2001 to 2010. Although there are no substantial variations for the average elderly income and the number of single elderly individuals, the number of foreign born elders, as well as the number of elderly individuals who work, differs by their location.

The elderly living in Jämtland and Gotland have the lowest annual income (185,000 SEK). Unsurprisingly, Stockholm shows much higher levels of elderly income (247,000 SEK per year) in comparison to the

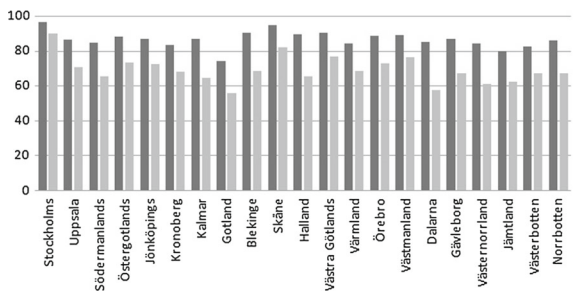


The rates of foreign born elderly, per 1000 population, 2010.

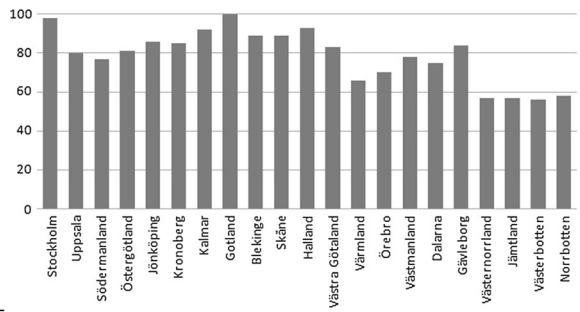


The average elderly income thousands Krona per year, 2010.

Fig. 2 The selected socio demographic characteristics of Sweden. *Data source*: Statistics Sweden, 2010



The percentage of the people having access to the grocery store in less than 5 minutes by car in dark bars, 2010.
The percentage of the people having access to the health care in less than 5 minutes by car, in gray dark, 2010.



The percentage of the paved street by county, 2010.

Fig. 3 The indicators of the accessibility by county in Sweden. *Data source*: Growth Analysis, 2010

average à yearly income of the older population living in other counties (197,000 SEK). The number of active older population is the lowest in Norrbottens, and most of the northern counties, while Stockholm and Uppsala show the highest rates of active elderly individuals. Interestingly, Stockholm and Uppsala represent the lowest number of older individuals who were single in 2010. The highest number was observed in Västernorrland county. Most of the foreign born elderly population lives in Stockholm and Västmanland (192 and 174 elderly people per 1,000 older population). However, a few foreign born elderly individuals live in the northern counties, such as Västerbotten, Västernorrland, and Jämtland (42.3 per 1,000 population in average). The exception is Norrbotten with 87 foreign born individuals per 1,000 population.

The level of accessibility in terms of distance to social services, as well as the number of paved streets, varies by county in Sweden. As shown in Fig. 3, 90 % of the population living in various counties can access the nearest grocery stores by car in less than 5 min. The number for ease of access to health care is noticeably lower (76 %). In particular, people living in the northern counties suffer from lower accessibility to healthcare services. Ninety-four percent of the population can reach the post office by car in less than 10 min, and about 80 % has access to an ATM in less than 5 min. In Sweden, there is an average of only 24 % unpaved county streets. For some of the Northern counties, the percentage of unpaved streets can reach up to 58 %.

Data and method

Statistics on 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 utilize more homogenous data, some of the fall codes were aggregated into four

Table 1 The data sets used in the study

Statistics	Source
Number of patients admitted in hospitals because of fall, by county, age group, gender, and the external causes of falls	Swedish National Board of Health and Welfare, 2001–2010
Number of elderly living in special housing	Swedish National Board of Health and Welfare from 2012
The percentage of the paved road by county	Growth Analysis 2010
The percentage of the people having access to the social services in less than 5 min	Growth Analysis 2010
The cost of the elderly care, by county	SKL, 2010
Sweden population, by county, age group, and sex	Statistics Sweden 2001–2010
Number of the foreign born Swedish older population	Statistics Sweden, 2010
The number of none worker Swedish elderly by county	Statistics Sweden, 2010
The number of single Swedish elderly by county	Statistics Sweden, 2010

main groups: falls that occurred on ice and snow and in connection to ice skate/board equipment (including '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'), falls from furniture (W05 'Fall from wheelchair', W06 'Fall from bed', W07 'Fall from chair', and W08 'Fall from other furniture'), falls from ladders (W11 'Fall on and from ladder', W12 'Fall on and from scaffolding', and W13 'Fall out of or through building or building structure', scaffolding, or building), and 'falls in and from stairs and steps'. Table 1 shows the data sets used in this paper.

The population data for counties is available on the Statistics Sweden webpage, by year, county, sex, and age group. The statistics relevant to the socio-demographic variables including marital status, the number of people in the working population, average yearly income, and the number of foreign born individuals by county were derived from Statistics Sweden, 2010. The socio-demographic data for the older population was also acquired from these statistics. The statistics on the cost for elderly care by municipality was presented in a report by The Swedish Association of Local Authorities and Regions (SKL, 2011). The data on the percentage of the population with access to the post office, grocery store, ATM, and health care by distance was obtained from Swedish Agency for Growth Policy Analysis. Furthermore, data on the percentage of paved streets per county was derived from Growth Analysis as well. The rate of fall per 100,000 elders was 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 (the total population of elderly women).

Exploratory Data Analysis (EDA) was used to visualize and plot the potential association between the rates of elderly falls and the socio-demographic/economic variables. Geographical Information Systems (GIS) were employed to map the rate of falls, which helped to identify the counties with the highest/lowest fall rates. The Kendall rank correlation coefficient was used to explore potential associations between, for instance, the rate of elderly falls and the elderly socio-demographic characteristics. The Kendall rank correlation coefficient is a non-parametric test used to assess the dependency between two variables. Since the number of counties in Sweden is only twenty-one (small sample with Gaussian distribution), the choice of a non-parametric test is reasonable. However, two non-parametric methods are available to examine the associations between the two variables: Spearman's rank correlation and Kendall's rank correlation coefficient. The choice of Kendall's rank or Spearman's rank correlation depends on the presence of a discrepancy between the ranks of the two dependent and independent variables. If there is a huge discrepancy, Spearman's correlation is more appropriate. In our data set, as there was a small discrepancy, Kendall's rank correlation was chosen to assess the dependency.

Results

In Swedish counties, as older adults continue to age, they are more prone to indoor falls resulting from slipping, tripping, stumbling, and falling from furniture, or from stairs and steps. However, with less physical activity, the rates of outdoor falls on and from ladders, scaffoldings, out of or through buildings or building structures decrease at older age.

Older women are 1.6 times more prone to fall in total than men at the county level, but this may vary by category of fall (Bamzar and Ceccato 2014). Men are more exposed to falls than women in outdoor environments due to ladder climbing, walking on scaffoldings, and falling through buildings or building structures.

There are also substantial geographic differences in the distribution patterns of fall rate types in Sweden. In 2010, the highest rates of falls were witnessed among the elderly living in the Northern counties. Figure 4 shows the geographical distribution of the rates of elderly fall in Sweden in 2010.

The Northern counties show the highest rates of falls caused by ice and snow, and snow equipment. Also, the Northern parts of Sweden tend to have higher fall rates caused by slipping, tripping, or stumbling, and fall from furniture. The Eastern counties showed higher rates of falls from stairs and steps, while the West accounted for falls from ladders, scaffoldings, or buildings. Finally, Southern Sweden is recognized for having the highest rates of unspecified falls (Bamzar and Ceccato 2014).

The results of the Kendall Test are shown in the Table 2. The Kendall τ coefficient and its significance value are also reported respectively in the following texts. The confidence interval is stated at the 95 % confidence level. For instance, these two numbers (0.545, 0.03) indicate the correlation coefficient and its significant value for the relevant test.

The results indicate that there is an association between the counties with higher rates of foreign born elderly, and the rates of fall in ice or snow, and due to the use of skate/board equipment. Counties with higher numbers of foreign born elderly are those with lower numbers of elderly fall in ice and snow (−0.371, 0.019). Counties with a higher number of male elderly foreign born individuals shows a lower number of male elderly falls in ice and snow and in connection to the skate/board equipment respectively (−0.390, 0.013).

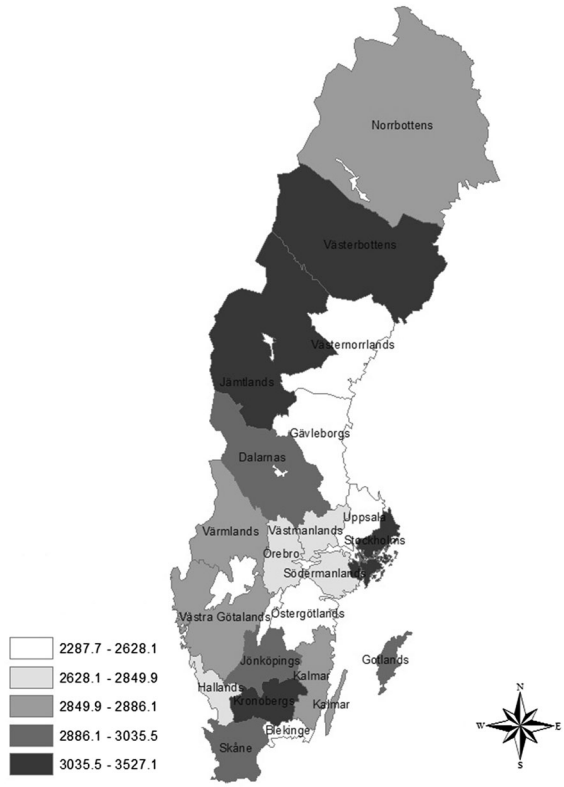


Fig. 4 The distribution of the rates of the elderly fall. *Source*: Swedish National Board of Health and Welfare, 2010. Statistics Sweden, 2010

Counties with lower average incomes for the elderly were associated with higher number of elderly falls caused by slipping, tripping, and stumbling (−0.329, 0.037). Furthermore, counties with lower average incomes for elderly men showed higher rates of elderly fall on ice and snow, and in connection with ice skate/board equipment for men (−0.343, 0.03).

Higher numbers of elderly falls on ice and snow for both sexes were significantly associated with higher costs of elderly care at the county level (0.0371, 0.019). Elderly men and women were both more prone to fall on ice and snow at the regional level in counties with higher costs of elderly care (0.324, 0.040 and 0.486, 0.002). The results also show that single elderly females are more likely to fall from furniture at the county level (0.352, 0.025).

Counties with a lower number of paved streets were significantly associated with higher rates of fall on ice

Table 2 Results of the Kendall test and significance levels

	Fall in ice and Snow	Fall by tripping	Fall from furniture	Fall from stairs and step	Fall from ladder	Total fall
Higher number of foreign born elderly						
Both sex	−0.371	−0.295	−0.286	−0.181	−0.210	−0.029
	0.019**	0.061	0.070	0.251	0.184	0.858
Female	−0.267	−0.267	−0.295	−0.133	−0.238	−0.095
	0.091	0.091	0.061	0.398	0.131	0.546
Male	−0.390	0.229	−0.181	−0.171	−0.162	0.086
	0.013**	0.147	0.251	0.277	0.305	0.587
Higher elderly income level						
Both sex	−0.234	−0.329	−0.158	−0.282	−0.196	0.177
	0.139	0.037**	0.319	0.075	0.215	0.264
Female	0.086	0.029	−0.152	−0.181	−0.114	−0.048
	0.587	0.858	0.334	0.251	0.469	0.763
Male	−0.343	−0.295	−0.057	−0.295	−0.095	−0.057
	0.030**	0.061	0.717	0.061	0.546	0.717
Higher no. of non-active elderly						
Both sex	0.181	0.048	0.229	0.200	0.190	−0.219
	0.251	0.763	0.147	0.205	0.227	0.165
Higher no. of single elderly						
Both sex	0.152	−0.286	0.124	0.114	0.219	−0.114
	0.334	0.070	0.432	0.469	0.185	0.469
Female	0.133	0.171	0.352	0.171	0.086	0.00
	0.398	0.277	0.025**	0.277	0.587	1.00
Male	−0.105	−0.210	0.010	−0.267	0.086	−0.276
	0.506	0.184	0.952	0.091	0.587	0.080
Higher cost of the elderly care	0.371	0.181	0.190	0.029	0.248	0.181
	0.019**	0.251	0.227	0.858	0.116	0.251
Higher prop. of elderly in special housing	0.162	−0.029	0.114	−0.124	0.152	0.067
	0.305	0.858	0.469	0.432	0.334	0.672
Higher no. of paved street	−0.421	−0.201	−0.201	0.115	−0.211	−0.019
	0.008***	0.204	0.204	0.468	0.184	0.904
Shorter distance to the grocery store	−0.486	−0.314	−0.210	−0.257	−0.324	−0.219
	0.002***	0.046**	0.184	0.103	0.040**	0.165
Shorter distance to ATM	−0.314	−0.181	−0.152	−0.238	−0.019	−0.048
	0.046**	0.251	0.334	0.131	0.904	0.763
Shorter distance to post office	−0.505	−0.424	−0.248	−0.181	−0.381	−0.124
	0.001***	0.007***	0.116	0.251	0.016**	0.432
Shorter distance to the health care	−0.396	−0.205	−0.263	−0.234	−0.081	−0.005
	0.012**	0.194	0.097	0.139	0.608	0.978

** Significant at 0.05, *** significant at 0.01

and snow, and in connection to ice skate/board equipment (−0.421, 0.008). Moreover, both elderly men and women are more likely to fall on ice and snow and in connection to the ice skate/board equipment in counties with a lower number of paved streets (−0.45, 0.004 and −0.325, 0.04). The rates of fall from ladder,

buildings, and scaffolding are higher for elderly men living in counties with a lower number of paved streets (−0.354, 0.025).

Counties with higher numbers of people with access to a grocery store in less than five minutes were significantly associated with lower numbers of elderly falls on ice and snow (−0.486, 0.002), falls caused by slipping, tripping, and stumbling (−0.314, 0.046), and falls from ladders, buildings, and scaffolding (−0.324, 0.04). At a regional level, elderly women were noted as more vulnerable to fall from ladders, buildings, and scaffolding (−0.410, 0.009), falls caused by tripping, slipping, and stumbling (−0.324, 0.04), in counties with a lower proportion of people with access to a grocery store in less than 5 min. Elderly women and men, respectively, are more prone to fall on ice and snow and in connection to the ice skate/board equipment, in counties with lower accessibility to a grocery store (−0.438, 0.005 and −0.467, 0.003).

Counties with higher rates of elderly fall on ice and snow (−0.505, 0.001) as well as falls caused by tripping slipping, and stumbling (−0.429, 0.007), and falls from ladders, buildings/scaffolding (−0.381, 0.016) were strongly associated with a lower number of people having access to the post office in less than 10 min. A similar pattern was found when it came to the gender perspective. The results of the Kendall Test confirm a negative association between the rates of falls on ice and snow for both elderly women and men, respectively (−0.457, 0.004 and −0.581, 0.000), as well as falls caused by tripping, slipping, and stumbling (−0.419, 0.008 and −0.362, 0.022), and falls from ladders, buildings/scaffolding (−0.448, 0.005 and −0.314, 0.046) and a lower accessibility to the post office.

Counties with a higher number of people having access to health care in less than 5 min showed the lowest number of falls on ice and snow and in connection to the ice board/skate equipment (−0.396, 0.012). For elderly women, the rates of falls on ice and snow, as well as falls from furniture were higher in counties with lower access to health care (−0.387, 0.014 and −0.368, 0.02). Furthermore, the rate of falls on ice and snow was higher in counties with a lower number of people with easy access to an ATM (−0.314, 0.046). However, the results do not show any significant association between the rates of falls and the number of elderly individuals living in special housing, as well as the number of inactive elderly individuals (elderly who do not work) at the county level.

Table 3 Main patterns of associations with elderly fall by county, 2010

Higher elderly fall	Lower elderly fall
Higher cost of the elderly care	Higher number of foreign born elderly
Higher number of single individuals	Higher elderly income level
	More paved streets
	Shorter distance to grocery store, ATM, post office and health care

Table 3 summarizes the results of this study. Overall, regardless of the type of fall, higher numbers of foreign born elderly individuals, and older population incomes, as well as higher levels of ease of accessibility to social services due to shorter distances, were all associated with lower rates of falls. Moreover, higher health care costs for the elderly, as well as higher rates of single elderly individuals, were both associated with higher rates of falls.

Discussion of the results

Counties with foreign born elderly population were also counties with the lowest number of elderly falls on ice and snow, and due to the use of ice skate/snowboard equipment. Several studies confirm the relationship between rates of fall and ethnicity in a geographical unit (Cauley 2011; Megyesi et al. 2011; Jacobsen et al. 1992; Penrod et al. 2008; Graham et al. 2008; Nguyen-Oghalai et al. 2009; Dhanwal et al. 2011). Furugren and Laflamme (2007) in a Swedish study also found that native Swedes are more likely to experience fall than foreign born older populations.

Non-native elderly individuals are more likely to live in larger urban settings in Sweden, rather than in rural areas. In more urbanized areas, the level of accessibility to social services, quality of street works such as paving, as well as, the speed at which snow and ice is removed, are all higher than in the rural areas. Therefore, foreign born individuals living in urban settings may be less likely to experience fall due to their living conditions. Furthermore, less exposure to sunlight may result in a shortage in vitamin D, and

consequently, less bone density among Swedish elders. This vitamin deficiency makes elderly individuals more prone to fall in comparison to elderly individuals born and raised in other geographical locations, such as the countries of the Middle East. However, the results of this study only show an association between the number of foreign born elders, and the rates of fall on ice and snow, rather than other fall type. Ethnic specific variations in bone density do not solely account for fall prevalence. Rather, differences in diet and lifestyle choices may further play a role. For instance, Swedish elders may be more interested than others in going skiing when it snows. Furthermore, foreign born elderly men are less likely to fall on ice and snow at county level. This may imply that foreign born elderly females are more prone to fall, as a result lower level of bone density, and osteoporosis-related diseases.

Fall related fractures caused by slipping, tripping, and stumbling are associated with lower levels of individual income at the county level. These findings are similar to studies showing income trends in fracture rates elsewhere (Trujillo et al. 2011; Kannus et al. 1999; Tinetti et al. 1988; Galizia et al. 2008; Luukinen et al. 1996). Households with higher incomes have better access to social services including health care services. Elders with higher incomes have better eating habits, and healthier lifestyles. They are also more likely to either live in a safer environment adapted for the needs of the elderly, or to pay for care services. However, elderly men with lower average incomes, were more prone to fall on ice and snow and in connection to ice skate/board equipment at the county level. A higher income may result in better mobility in ice and snow conditions, based on the choice of living conditions. Furthermore, there are some optional safety choices when skiing/skating which may not be affordable to those with lower incomes.

Counties with higher numbers of single elderly women were associated with higher rates of fall from furniture. Studies confirm the relationship between the prevalence of fall and marital status (Van Rossum et al. 2000; Haan et al. 1987; Lopata 1982). Overall, living alone and being single are connected to a higher chance of fractures (Hokby et al. 2003; Cakar et al. 2011). The literature indicates that single elderly women, due to the lower levels of physical activity, and lack of a social network, may spend most of their time at home, and participate in activities involving furniture more so than men. This may increase the likelihood of a fall. In confirmation with the previously stated hypothesis, there is an association between the rate of elderly falls and higher numbers of non-Swedes, higher income levels, and higher numbers of non-married individuals.

The results unexpectedly indicate that the counties with higher rates of elderly fall on ice and snow are also those with higher elderly care costs per municipality. The reason might be that municipalities allocate more money to counties with higher numbers of elderly health issues, including fall related fractures. However, no association has been found between the rates of elderly falls and the proportion of the elderly living in special housing. We do however confirm the second part of the hypothesis, suggesting that counties with higher elderly care costs show lower rates of falls among seniors.

Expectedly, counties with a higher number of paved streets were those with lower rates of falls on ice and snow. Paved streets with proper drainage systems provide seniors with safer walkways and sidewalks, particularly in the winter months.

The results of the Kendall Test confirm the association between ease of accessibility and lower rates of falls among the elderly at the county level in Sweden. Counties with a higher number of people with shorter distances to social services were also counties with lower rates of seniors experiencing falls on ice and snow, and in connection to ice skate/snowboard equipment. Although mobility is an essential factor to live a healthy life in old age, longer distances may result in higher fall rates amongst the elderly, particularly in ice and snow conditions. Furthermore, falls caused by tripping, slipping, and stumbling, as well as fall from ladders, buildings/scaffolding were related to longer distances to the grocery store, and post office. Longer distances to travel to social services may cause older men to make fewer trips, which would consequently limit their activity, and decrease mobility. This decreased mobility may result in a higher vulnerability to falls, due to a lack of muscular strength and proper physical functioning in terms of balance and walking speed. Thus, the third hypothesis is confirmed, indicating that the lower number of elderly falls, the higher number of paved streets at county level. Also, counties that show lower proportions of elderly individuals with shorter distances to

basic services (grocery stores, ATM, health care center, and post office), tend to have lower fall rates. Moreover, some studies suggest that the presence of adequate and proper access to health care and social services may result in longer lifespans (Andersen 2008; Landi et al. 2001; Sandberg et al. 2012).

Conclusion

This study examines the associations between the rates of falls amongst the elderly, and the ecology of the selected socio-demographic characteristics of Swedish seniors at the county level. Our findings show that different parts of Sweden show different vulnerabilities for the elderly with regards to falls at an ecological level. For instance, the North represents the highest rates of falls by seniors on ice and snow, as is to be expected. The West showed the highest rates of falls from ladders, buildings, and scaffolding for seniors. The eastern part of Sweden showed the highest rates of seniors being injured as a result of a fall from steps and stairs. However, the results of the Kendall test indicate that some ecological factors influence this geographic variation. The results show some significant associations between the rates of falls amongst seniors, and the set of selected socio-demographic/economic factors, as well as the cost of elderly care, and accessibility measures at the county level. The counties with the lowest proportion of non-Swedes, higher proportions of elderly individuals with low incomes, and single seniors, showed significant association with higher rates of falls. Furthermore, the counties with higher levels of accessibility, with regards to the number of paved streets, shorter distances to social services, and the grocery store, had lower rates of falls. Surprisingly, the counties with the highest rates of elderly fall were those with the highest costs for elderly care. This may imply that municipalities are trying to deal with the problem of high fall rates by allocating more money to care for the elderly. However, no clear associations have been found between the rates of the elderly fall and the number of seniors living in special housing at the county level. This means that, although there is a tendency for seniors to want to stay at their own home, the rates of falls amongst the elderly in special housing is significantly low, perhaps due to the fact that special housings are more adapted to the needs of its seniors.

The results of this study also indicate the associations between higher rates of falls, and lower levels of accessibility. More studies are needed to identify and analyze the patterns of the daily journeys of the older population, including how far the destination is, and at what time the journey is taken.

Vitamin D deficiency, exposure to sunlight, and living in rural areas associated with lower levels of accessibility, are some of the possible explanations as to why native Swedish seniors are more prone to fall rather than other ethnic groups. However, more investigation is needed to identify which foreign born ethnic groups are less vulnerable to incidents involving falling by geographic location at the county level, and to examine the presence of any differences between the least/most vulnerable groups with regards to lifestyle, environmental hazards, and risk-taking activities.

Future research is needed to assess how income may directly influence the lifestyles of the older population, specifically drinking and eating habits, and how this may affect the prevalence of fall incidents amongst Swedish seniors. Moreover, the lack of a strong social network and immediate support with regards to dealing with furniture and housing issues, may explain why single elderly women are more likely to fall than elderly men. This group could take priority when it comes to assigning care givers and nurses to the elderly by policy makers.

Using aggregated data at the county level in this study makes it possible to provide a broader image of the impact of socio-economic/demographic factors, accessibility measures of social services, and the costs of elderly care on the rates of falls amongst seniors. At the ecological level, the results of this study may point to some fall prevention measures with regards to the elderly; however future research should explore the presence of causal links between elderly fall and environmental factors at the individual level, with regards to the importance of geographical context. The findings of this study should be regarded in light of several limitations. First, like other cross-sectional studies, the results of this study are related to the specific time period (2010), and the relevant conditions. Thus, the results

and the suggestions cannot be generalized for other contexts and situations. Although in-patient data covers more serious injuries, using in-patient data in the analysis usually relies on the number of fall records with no need for hospitalization. Furthermore, the presence of differences in the recording and reporting of incidents, as well as taking into consideration human error at such a large geographical scale (Swedish counties) should be regarded as another limitation. Due to the lack of data, this study fails to explore the factors relevant to the lifestyle of the elderly, their health status, and their social connectedness. There is also need to investigate the impact of other environmental factors, and in particular physical environment at a local level, using modeling to explore possible causalities between environment characteristics and fall rates.

Accessibility planners should consider the barriers for the pedestrians' journey, including inappropriate sidewalks, and the poor quality of street paving, especially in winter. Furthermore, having closer social services, as well as high quality street paving, could be regarded as fall prevention measures for the elderly. Installing more seats in public spaces, and in particular on the way from elderly homes to these social services, providing delivery services for food, or daily shopping, especially in winters, could be suggested as other fall prevention strategies. Municipalities have to begin assigning more money to areas lacking proper facilities to care for the elderly. Wearing safe shoes and slippers could also play a major role in preventing falls caused by slipping and tripping, both indoors and out. For instance, slippers with open backs, and shoes without proper support, increase the risk of falling for seniors. This study suggests the five suitable target groups for fall prevention programs at the county level in context to Sweden: the Swedes native seniors, seniors with low income levels, single elderly women, seniors living in rural areas with improper street pavement, and low levels of accessibility to social services. The localities and care giver authorities could design educational programs for the elderly in order to prevent falls by considering the socio-demographic characteristics of the target elderly group.

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