Stockholm Research Reports in Demography | no 2019:10

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ISSN 2002-617X | Department of Sociology

Stockholm University
Demography Unit

Regional trajectories in life expectancy and life-span variation: Persistent inequality in two Nordic welfare states

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Abstract

An important source of inequality in mortality is regional variation. However, studies that investigate regional mortality patterns within and across national borders are extremely rare. We respond by carrying out a comparative study of Finland and Sweden: two welfare states that share many attributes, with one exception being their mortality trajectories. While Finland has risen rapidly in the global life expectancy rankings, Sweden has lost its historical place among the top ten. Using individual-level register data, we study regional trends in life expectancy and life-span variation by sex. Although all regions, in both countries, have experienced substantial improvements in life expectancy and lifespan inequality from 1990-2014, considerable differences between regions have remained unchanged, suggesting the existence of persistent inequality. In particular, Swedish-speaking minority regions in Finland had maintained their mortality advantage over Finnish-speaking regions. Nevertheless, there is some evidence of convergence between the regions of Finland and Sweden.

Keywords: *Mortality, Life expectancy, Life-span variation, Regional, Inequality, Nordic, Sweden, Finland*

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ISSN 2002-617X

Introduction

One of the most important indicators of human development is how long people live (UNDP 2017). Global development is measured, at least in part, by examining whether the differences in life expectancy between countries are growing or shrinking (Marmot 2005). Similarly, within-country inequalities in life expectancy are indicators of national development, societal fairness, and social justice (Marmot et al. 2010). It is well-known that comparisons of mortality within countries can paint a different picture from comparisons between countries, not least because *"national mortality rates can mask significant regional variations"* (Shaw et al. 2000, 1055). One of the well-known dimensions of inequality in European mortality is regional variation, and a variety of studies have shown that there are considerable differences between European regions in their all-cause and cause-specific mortality rates (Shaw et al. 2000; Eurostat 2002; Müller-Nordhorn et al. 2008; Seaman et al. 2015). Regional differences are of vital importance to the study of mortality inequalities because these differences do not only reflect variation in individual characteristics across local populations, but also variation in contextual factors such as social cohesion, physical infrastructures, and economic environments (Montez, Zajacova, and Hayward 2016).

In this study we take an innovative approach to conceptualising mortality inequality by focussing on regional trajectories, not only with respect to life expectancy, but also life-span variation. Rather than studying the determinants of regional variation, here we build upon recent developments that recognize the importance of studying the dynamics of mortality inequality. Demographers have increasingly called for supplementing central longevity indicators (mean, median, and modal age at death) with measures of variability in length of life (OECD 2007; van Raalte, Sasson, and Martikainen 2018). National populations can greatly differ with respect to life-span variation, even at the same levels of life expectancy (Vaupel, Zhang, and van Raalte 2011). Measures of life-span variation complement life expectancy and indicate both heterogeneity in underlying population health (Edwards and Tuljapurkar 2005) and individual uncertainty in the length of life (Edwards 2013). However, most of what we know about life-span variation is based on prior research that almost exclusively focusses on national trends or differences between social groups within or between different nations (Vaupel, Zhang, and van Raalte 2011; van Raalte et al. 2011; Sasson 2016).

Here, we therefore break new ground by studying life-span variation at the regional level. To do this, we undertake a comparative study of Finland and Sweden. We study their regional trajectories in life expectancy at birth, alongside regional trajectories in life-span variation (using the Gini coefficient of ages at death). Whereas the former indicates disparities *between* regions in average longevity, the latter indicates equality in length of life *within* regional populations. Few studies have documented trends in life-span variation within countries (although see: Sasson 2016; van Raalte, Martikainen, and Myrskylä 2014; Permanyer et al. 2018) and none, as far as we know, have studied spatial trends in life-span variation at the subnational level, including for regions.

One benefit of comparing regional mortality in Finland and Sweden is that they have very different national mortality trajectories. For more than one hundred years, Sweden has been one of the global leaders in life expectancy (Oeppen and Vaupel 2002; Vaupel, Zhang, and van Raalte 2011). However, since the 1980s for women, and the 2000s for men, Sweden has lost its place in the top of the global rankings for period life expectancy (Drefahl, Ahlbom, and Modig 2014). Sweden has lost ground, relative to other leading countries because mortality at higher ages has declined more slowly; however, it has not been possible to isolate one single explanatory factor for this trend. By comparison, life expectancy in Finland was much lower at the turn of the Twentieth Century, and Finland was much slower to experience the transition from high to low mortality (Turpeinen 1979). Despite this, the rate of mortality improvement in Finland has been considerable over the last few decades, in particular from the 1970s onwards (Kannisto et al. 1994). As such, life expectancy in the two countries is now much more similar than in the past (Marmot, World Health Organization, and UCL Institute of Health Equity 2014). It is therefore of considerable interest to examine whether this national convergence has led to similar convergence in life expectancy at the regional level, as well as an accompanied convergence in regional inequality levels. This question is of broader interest than the Nordic context, in particular because of the large number of countries across the globe that are projected to converge to a low mortality regime over the coming decades (UN 2013). Although we have seen a long-run convergence in national life expectancies across the globe (Wilson 2001), there seems to be no evidence that shows whether regional life expectancies are converging over time, nor any evidence about the convergence of regional life-span inequalities, in Europe or elsewhere. This is an important gap because regional trajectories may differ from national trajectories.

Despite what is known about regional differences in all-cause mortality, the literature consists almost entirely of single country studies of life expectancy at birth (e.g. Langford and Bentham 1996; Luy 2004; Saarela and Finnäs 2006; Marmot et al. 2010; Kibele and Janssen 2013; Statistics Sweden 2016). Only a small number of cross-national comparisons have been made, and these appear to be limited to large-scale cross-sectional estimates of regional mortality (e.g. a study of standardised mortality ratios for NUTS2 [Nomenclature of Territorial Units for Statistics] regions in 15 European countries, see: Shaw et al. 2000). As such, there is an absence of studies that examine regional mortality in detail, especially comparative studies, such as those that compare regions in similar neighbouring countries. This is an important gap in the literature because comparative case studies are one of the best means of testing the generalisability of research conclusions and restricting the number of competing explanations for observable patterns of aggregate behaviour (Gerring 2004). For an analysis of regional mortality trajectories, therefore, a comparative case study is most appropriate for regions that share many factors – including factors that are shared at the national level, such as levels of public spending or the availability of healthcare – as well as factors that are shared between regions in the countries that are being compared, such as those relating to geographical proximity, climate, and distance from major metropolitan cities.

Here, we carry out a comparative study of regional mortality in Finland and Sweden, and there are several reasons why these two countries are appropriate for a comparative case study. As mentioned, they differ in one important aspect – namely their national mortality trajectories – but they are otherwise similar in a considerable number of respects. First, they are neighbours, with a shared history and similar social, political and environmental conditions. For example, both countries have a common (open) border, and a shared geography. In both countries, the locations of the capital and the other largest cities are in the south, with more remote and less densely populated regions in the north. Second, both countries have a strong welfare state, as demonstrated by their similar levels of social, health and welfare spending (per capita), which are among the highest in Europe (Marmot, World Health Organization, and UCL Institute of Health Equity 2014). Third, life expectancy is currently high and continues to improve in both countries. Taken together, these similarities imply that we can expect regional inequality to be low in both countries. These similarities also imply that the two countries are comparable, such that observed differences in their mortality patterns are attributable to a smaller number of factors (than for comparisons between other country-dyads).

Nevertheless, there are some other important differences between the countries. In particular, the history of the Swedish colonisation of Finland, which began more than 500 years ago, and has led to the existence of Finnish regions that are populated to a great extent by the descendants of Swedish immigrants. Finland was part of the Kingdom of Sweden until 1809, when it became a Grand Duchy under Russian rule, which became independent from Russia in 1917. As a result of this history, there are some regions – albeit limited in number – that have significant populations of Swedish-speakers (e.g. Ostrobothnia). Although this difference makes regional comparisons a bit more complicated, it also means that our study is not only able to compare Sweden and Finland, but also Sweden and the regions of Finland that are home to a significant number of Swedish-speakers. This comparisons is of additional value because it can help to disentangle the role of national and subnational differences.

In the analysis that follows we carry out a comparative case study using harmonised whole-population register data for Finland and Sweden. We use these data to estimate regional life expectancy and life-span inequality over a 25-year period from 1990-2014. Our main research questions are as follows:

(1) *What are the regional differences in life expectancy at birth and life-span variation in Finland and Sweden, and how have differences within and between the two countries changed over time for women and men?*

(2) *Have life-span inequalities within and between regions increased or decreased over time, and does this depend on whether we measure inequality using life-span variation, rather than differences in average mortality?*

(3) *What is the relationship, at the regional level, between changes in life expectancy and changes in life-span variation?*

With these questions, we aim to generate new insights into the dynamics of life expectancy and life-span variation at the regional level. We seek to understand how regional inequality has changed over time, where inequality is evaluated through several different comparisons. First, we compare the differences *between* regions, in terms of life expectancy and life-span variation. Second, we compare the differences *within* regions – in terms of life-span variation. These differences are evaluated over time, for men and women, and can be used to compare both *between* and *within* countries. Through the scope of these comparisons, we believe that we are taking an innovative approach to conceptualising regional mortality inequality. We also consider a question that is specific to our context, which is whether regional trajectories are different for the predominantly Swedish-speaking regions of Finland, as compared with regions

in Sweden or the rest of Finland. The answer to this question will help to show the importance of (historical) population composition in determining regional mortality trajectories. However, we note that there are relatively few regions in Finland that have significant numbers of Swedish-speakers, and hence regional differences are hard to attribute to this factor alone, even with respect to associations.

Although there have been no previous studies of all-cause mortality comparing Finland and Sweden, there have been studies of each country in isolation, including some studies of regional mortality. In the next section, we summarise this previous research in order to provide background for our analysis that follows. We note that here, in common with most previous studies, regions are defined to be 'counties', referred to in Sweden as *Län*, and in Finland as either *Maakunnat* (in Finnish) or *Landskap* (in Swedish). These are equivalent to level three when using the Nomenclature of Territorial Units for Statistics (NUTS) developed by the EU.

Our current understanding of regional mortality in Finland

There are three recurrent themes in the Finnish literature on regional variation in mortality. First, clear differences are observed between *(1) North and East Finland*, *(2) South and West Finland*, and *(3) Helsinki-Uusimaa* (i.e. the capital city of Helsinki and the surrounding region). In particular, regions in the south and west are consistently observed to have lower mortality than in the north and east, both by region of birth and by region of residence (Saarela and Finnäs 2006, 2010). We discuss the differences between these three distinct areas of Finland in more detail below. Second, differences are observed between Swedish-speaking and Finnish-speaking Finns. Swedish-speakers have lower mortality than Finnish-speakers living in the same area (Saarela and Finnäs 2005, 2010, 2011; Sipilä and Martikainen 2009). Third, there is no single factor that appears to explain regional differences. Observed patterns appear to be a result of social, environmental, and genetic factors.

Mortality rates in *North and East Finland* [1] are observed to be consistently the highest in the country (e.g. Saarela and Finnäs 2006, 2010, 2011). In addition, the mortality of people living in other areas of Finland (i.e. the south or west) is higher if they were born in the north or east (Saarela and Finnäs 2010, 2011; Elo, Martikainen, and Myrskylä 2014). The persistence of regional differences even appears to have an intergenerational dimension. Mortality is higher for people born in the south/west if they have parents who were born in the north/east (Saarela and Finnäs 2006). The reasons for these patterns are less clear, but two main arguments have been put forward. First, a number of studies suggest that risky health behaviour is more widespread in the north/east (Saarela and Finnäs 2006; Elo, Martikainen, and Myrskylä 2014).

It has also been argued that genetic differences have helped determine this increased mortality, the evidence being that parental birth in the north/east is predictive of lower life expectancy (Saarela and Finnäs 2006, 2010, 2011). Saarela and Finnäs suggest that this genetic variation has arisen as a result of historic differences between the populations living in the north/east and south/west, and that low migration from the south/west to the north/east (as opposed to from east to west) has reaffirmed low genetic diversity in that region (2010).

Compared to the north and the east, *South and West Finland* [2] has lower mortality rates. This low mortality may be partly explained by the fact that most of Finland's Swedish-speaking population reside in the south-west of Finland, particularly in Helsinki and the Ostrobothnian regions (of which there are several, one of which is called 'Ostrobothnia' in English). Ostrobothnia is the only region of Finland where the Swedish-speaking population is larger than the Finnish-speaking population, but there are other regions with significant Swedish-speaking populations, in particular Southwest Finland and Helsinki-Uusimaa. Swedish speakers in Finland have lower mortality rates than Finnish speakers (Saarela and Finnäs 2005, 2010, 2011; Sipilä and Martikainen 2009), which is expected to contribute to lower overall mortality rates in Swedish-speaking regions. Related to this is the fact that regional mortality trajectories are likely to have their origin in the historical connections between Sweden and Finland (Pitkänen and Mielke 1993). For example, historical studies have shown that patterns of mortality were notably similar for Stockholm and the (Swedish-speaking) 'Bothnian' parishes of Finland (Turpeinen 1978).

The region of *Helsinki-Uusimaa* (i.e. Uusimaa, including the capital city of Helsinki) is treated separately in many analyses due to it being the location of the largest city in Finland, and therefore having considerably different attributes from the surrounding regions. A number of studies have found this to be reflected in its mortality patterns, in particular mortality rates in the Helsinki area are disproportionately higher than the other regions in the south-west (Saarela and Finnäs 2006, 2011).

Our current understanding of regional mortality in Sweden

Although there is a well-established literature on regional mortality in Finland, the same is not true for Sweden. Much of what is currently known is based on official government statistics and publications from Statistics Sweden (SCB). Like Finland, Sweden can be roughly divided into three distinct areas (often called the 'lands of Sweden'): *North Sweden* (Norrland), *Middle Sweden* (Svealand) and *South Sweden* (Götaland).[3] North Sweden is the largest of the three, while the other two are geographically smaller but contain the most highly populated urban areas. Official statistics show a general pattern of higher mortality in the north, such that regions in North Sweden have the highest levels of mortality, while regions in South Sweden generally have the lowest (Statistics Sweden 2016).

Compared with the rest of the country, *North Sweden* [4] includes many of the largest and most sparsely populated regions, both by population density and total population, with most of the population concentrated in urban areas along the (northeast) coastline. In general, regions in North Sweden have a lower life expectancy at birth than those that are located further south, but there is broadly similar evidence of improvements in life expectancy every decade for regions in North Sweden, since 1970, as there is for other regions of the country (Statistics Sweden 2016). More recently, Andersson and Drefahl (2016) found no significant mortality differentials between people living in the north of Sweden as compared with the rest of the country. However, they did find that internal migrants from north to south Sweden had significantly higher mortality, compared to non-migrants in either the north or the south, if they returned to North Sweden.

On average, the mortality profile of *Middle Sweden* [5] is somewhere between North and South Sweden. Its regional life expectancies are generally lower than the South and higher than the North, although there is large variation by region (Sans, Kesteloot, and Kromhout 1997). Some regions are consistently in the higher quartiles by life expectancy (Stockholm and Uppsala) and some are in the lower quartiles (Örebro, Södermanland, and Västmanland). Stockholm in particular has relatively high life expectancy compared to surrounding areas (Statistics Sweden 2016). On the other hand, *South Sweden* is marginally larger than Middle Sweden by area and is more populated than both North and Middle Sweden. It also contains two of Sweden's major population centres in Gothenburg and Malmo.[6] In previous studies, South Sweden has been found to have higher life expectancy than Middle or North Sweden (Sans, Kesteloot, and Kromhout 1997).

Our current understanding of sex differences in Nordic regional mortality

Studies of sex differences in mortality in the Nordic countries do not appear to have incorporated a regional perspective (Oksuzyan et al. 2008), although regional life expectancy data are sometimes used to study this topic (Cullen et al. 2016). Similarly, studies of regional mortality typically go no further than a broad discussion of aggregate differences between women and men at a specific point in time, sometimes even combining men and women in the analysis (Shaw et al. 2000). As discussed above, previous research has yet to focus on differences in life expectancy and life-span variation, by region and sex, and how these differences vary over time. Similarly, with the exception of a single study of mortality in the 18th Century (Turpeinen 1978), there have been no previous comparisons between the regions of Finland and Sweden. Based on official statistics, we know that female life expectancy is higher than male life expectancy in all regions of Finland and Sweden (Statistics Finland 2014; Statistics Sweden 2016). However, aside from this fact, little is known about regional mortality differences by sex. One other finding of note is that the difference in mortality between Swedish-speaking and Finnish-speaking women is somewhat smaller than between Swedish-speaking and Finnish-speaking men (Sipilä and Martikainen 2009).

Data and method

We use data for the whole population of both Finland and Sweden. Our data are obtained from register-based administrative sources that are managed by the national statistics agencies of the two countries. To calculate the trajectory of mortality in each region – for the measures of life expectancy and life-span variation described below – we used annual data for 25 consecutive years, from 1990-2014. This was the longest period for which we were able to obtain comparable annual data.

Our analysis is based upon registered deaths and population counts – by age, sex, region and year – for the entire population of both countries. Although our data are at the individual level, in practice our life tables are based upon aggregate annual counts of the total number of deaths and total number of people by single year of age, sex, region and year. These totals are used to create stratified life tables for men and women in each region for each year, which in turn are used to estimate e_0.

We use a standard life table approach for the analysis of variation in period life expectancy at birth (e_0). In essence, we estimate age-specific all-cause mortality risks, separately for women and men, in each region of Finland and Sweden. We make use of regional data for Finland and Sweden at what is often referred to as the county-level, or perhaps more precisely as the level of NUTS-3 units (using EUROSTAT definitions for harmonised regional geographical units). There are 21 of these regions in Sweden and 19 in Finland. However, two are relatively small island regions – Åland in Finland and Gotland in Sweden – so we omit them from the analysis, leaving 38 regions in total. Although we recognise that results will depend upon the size or type of geographical unit that is chosen (the so-called modifiable area unit problem), we believe that these regions represent an appropriate unit of analysis. In part, this is because they constitute distinct administrative units which vary in their economic environments, physical and health infrastructures, and socio-cultural characteristics.

In addition to estimating life expectancy at birth (i.e. the life table mean age at death), we also use the life table to estimate ages at death around this mean. In other words, we estimate inter-individual variability in length of life, a measure of life-span inequality (van Raalte, Sasson, and Martikainen 2018). We do this by estimating a Gini coefficient of ages at death (Shkolnikov, Andreev, and Begun 2003), which we refer to here as G_0. In essence, this is the same measure that is used to measure income inequality, but applied to ages at death. We note that there are alternative ways of measuring life-span variation, but they are highly correlated with the Gini coefficient (van Raalte and Caswell 2013).

Results

Before examining regional variation in life expectancy in Finland and Sweden, it is useful to examine national variation. In both countries, life expectancy has improved over the last fifty years. However, the improvement for Finland has been much faster than in Sweden, for both women and men. Improvements in Finnish life expectancy have led to Finland rising in the global rankings for national life expectancy, as opposed to Sweden, which has fallen from its position as a global leader (Drefahl, Ahlbom, and Modig 2014). As shown in Figure 1 below, these changes have led to a narrowing of the difference in period life expectancy between Finland and Sweden. By the turn of the 21st Century, there was almost no difference for women, and only a difference of around three years for men, as compared with almost ten years difference in 1950.

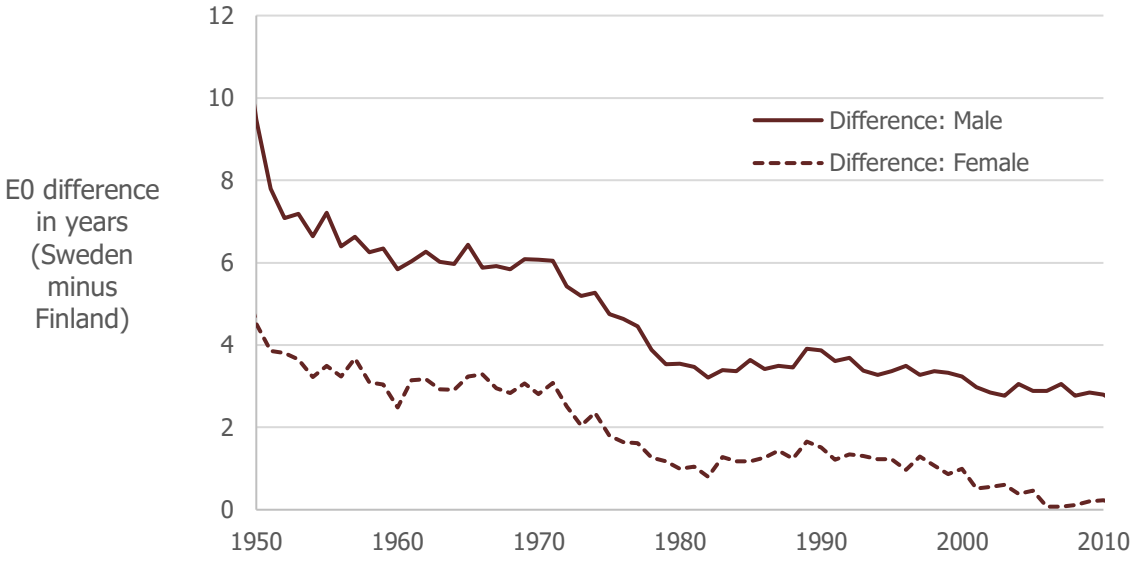


Figure 1 Difference (in years) in life expectancy at birth between Sweden and Finland

Note: Calculations based on national life tables produced by Statistics Sweden and Statistics Finland.

National data can also be used to calculate trends in the sex-difference in mortality (i.e. the difference between women and men). Despite considerable improvements in Finnish life expectancy, in particular as compared with Sweden, the sex-difference in all-cause mortality has remained broadly constant since 1950. The sex-difference in both countries increased from 1950 to 1980, and then declined from 1980 to 2010. Nevertheless, the female advantage in e_0 has consistently been about two years larger in Finland as compared with Sweden, and this remains the case most recently.

Period life expectancy by region

To some extent, the regional trajectories for life expectancy in Finland and Sweden are aligned with their respective national trajectories. Over the twenty-five years from 1990-2014, all regions have experienced improvements in average life-span at birth (e_0). Figure 2 shows the average life-span for women (top panel) and men (bottom panel) by region. It combines Sweden and Finland, with the regional levels of life expectancy at birth mapped separately in 1990 (left) and 2014 (right) by sex. The aim of this analysis is to demonstrate the general trajectory of regional inequality, for men and women, both within and between the two countries.

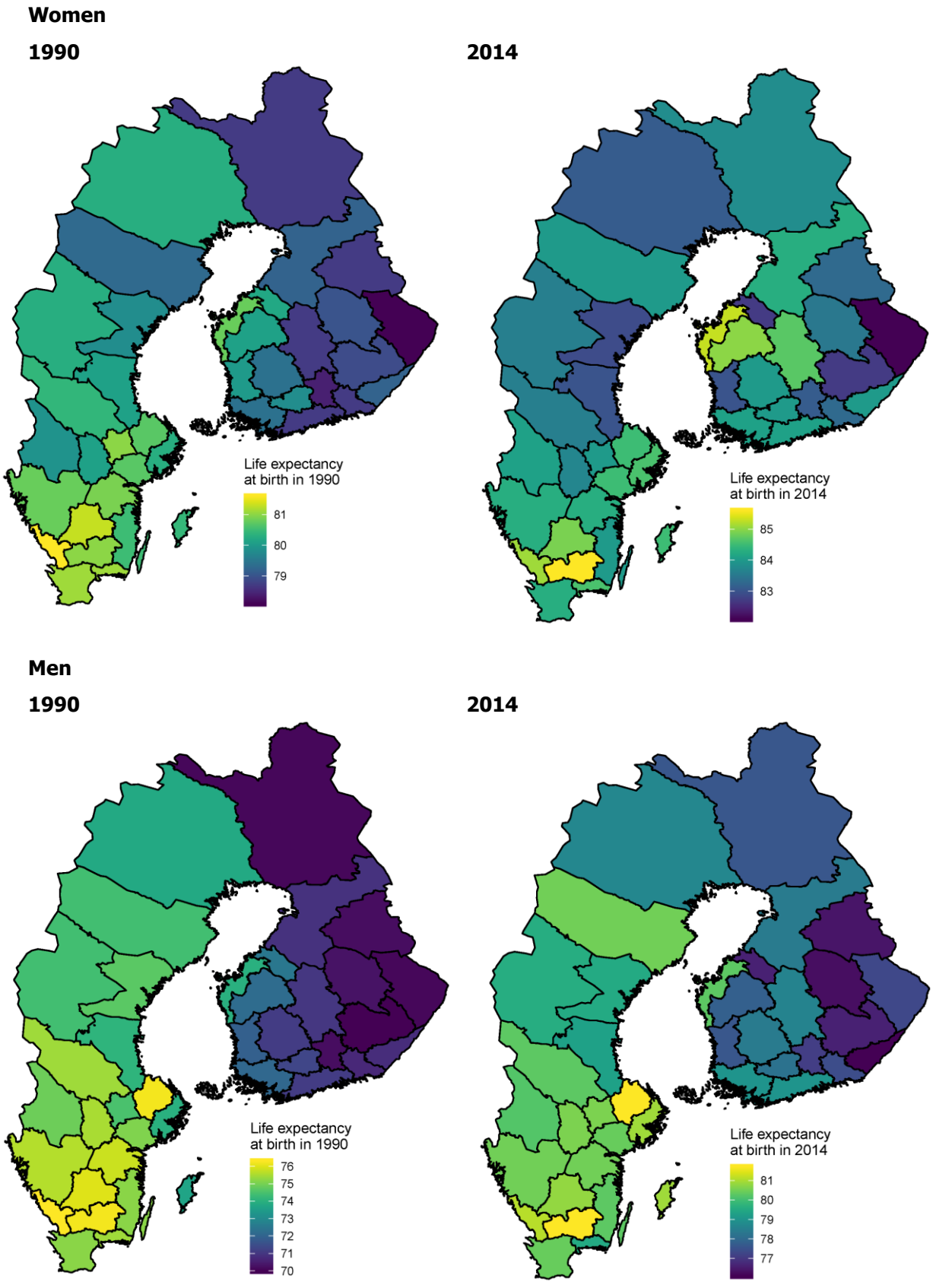


Figure 2 Maps of regional life expectancy at birth for Sweden and Finland

Note: Regions are shaded according to their relative life expectancy in each map, which effectively indicates the rank of each region across both countries in 1990 or 2014, separately for women and men.

One of the most notable findings is the difference in regional life expectancy trajectories by sex. In 1990, regional patterns for men and women are very similar. Almost all Finnish regions have lower life expectancy than all Swedish regions. For men, the only exception is Ostrobothnia, and for women it is Ostrobothnia, Central Ostrobothnia, and Kanta-Hame. As noted above, Ostrobothnia is the only region in Finland that has a greater proportion of Swedish-speakers than Finnish-speakers.

More than two decades later, in 2014, this pattern remains largely unchanged for men, such that Ostrobothnia remains the only Finnish region with better average male life expectancy than Norrbotten, which has the lowest life expectancy of any region in Sweden (see Appendix Table A1 for rankings of all regions in 2014, including the region names). This stability in regional rankings is in stark contrast with the same rankings for women. Since 1990, Finnish regions have caught up with Swedish regions – and in some cases overtaken them – with respect to female life expectancy at birth. In 2014, seven of the eighteen regions of Finland are above the median regional life expectancy for the 40 regions of Finland and Sweden. Even more notable, perhaps, is the fact that the top-ranking region for female life expectancy in 2014 is a Finnish region – Ostrobothnia.

Although these differences between men and women are very striking when comparing across countries, within Finland or Sweden the regional rankings for men and women are generally consistent, and align with the results of previous research. They confirm a persistent difference between the north and the south of Sweden, as well as a south-west/north-east divide in Finland.

Perhaps unsurprisingly, three of the regions of Finland that have risen to the top of the rankings are those with the largest proportion of Swedish-speakers (Ostrobothnia, Southwest Finland and Southwest Finland and Helsinki-Uusimaa). For female life expectancy, these regions rank higher than many Swedish regions in 2014, in particular those in North Sweden. They also rank higher than almost all of the Finnish-speaking regions of Finland, with the exception of the other Ostrobothnian regions (North, South, and Central). Our results therefore align with micro-level analysis that shows a consistent longevity advantage for Swedish-speakers.

Figure 3 Trends in maximum and minimum regional life expectancy (e_0) and lifespan variation (G_0) by sex

Note: Each plot shows the trend for the highest and lowest region in each year by country, for either e_0 (in the top two panels) or G_0 (in the bottom two panels), separately for women and men.

Analysis of life-span variation

Having examined regional trajectories in life expectancy, we turn our attention to our second research question, which asks whether regional inequalities in life-span variation have increased or decreased over time. To answer this question, we move beyond the most common approach for studying mortality inequalities – namely, to analyse differences in life expectancy (e_0) – and analyse variation in age at death within each region. For this we use the Gini coefficient (G_0).

Figure 3 provides an overview of regional inequality trajectories using both measures. In each panel, we show the trajectory for the regions that exhibit the highest and lowest life expectancies in their respective countries in each year. This figure therefore provides a trajectory-line for the best and worst region in each country, such that all other regions are contained within the bounds of these two lines. For life expectancy at birth (the top two panels), the general trajectory reflects a similar improvement of about two years per decade, for both the best- and worst-performing regions in each country, by sex. In general, improvements over the whole period of 1990-2014 have been greater in Finland. For example, this can be seen by looking at the convergence of the lines for Finland and Sweden in Figure 3 for female life expectancy (the top-right panel).

This pattern of universal improvement can be juxtaposed with the persistence of regional inequality. The gap between the 'best' and 'worst' region in both countries is pretty much constant over our study period, and although there is no sign of this gap widening, there is also no sign of it becoming smaller. For women in both countries and men in Sweden, the gap is around two years. For men in Finland, the gap is closer to four years.

These results for life expectancy at birth (in the top two panels) can be contrasted with the same analysis for life-span variation (in the bottom two panels). Although they are a little more erratic year-on-year, the trajectories for regional life expectancy variation also show a general pattern of improvement. From 1990-2014, there has been a general decline in life-span variation (of between 0.01 and 0.03 units), which indicates a reduction in life-span inequality within regions. At the same time, the gap in each country between the region with the highest and the lowest life-span variation has remained broadly constant (at around 0.02 units). However, as with life expectancy, this gap is much larger for Finnish men.

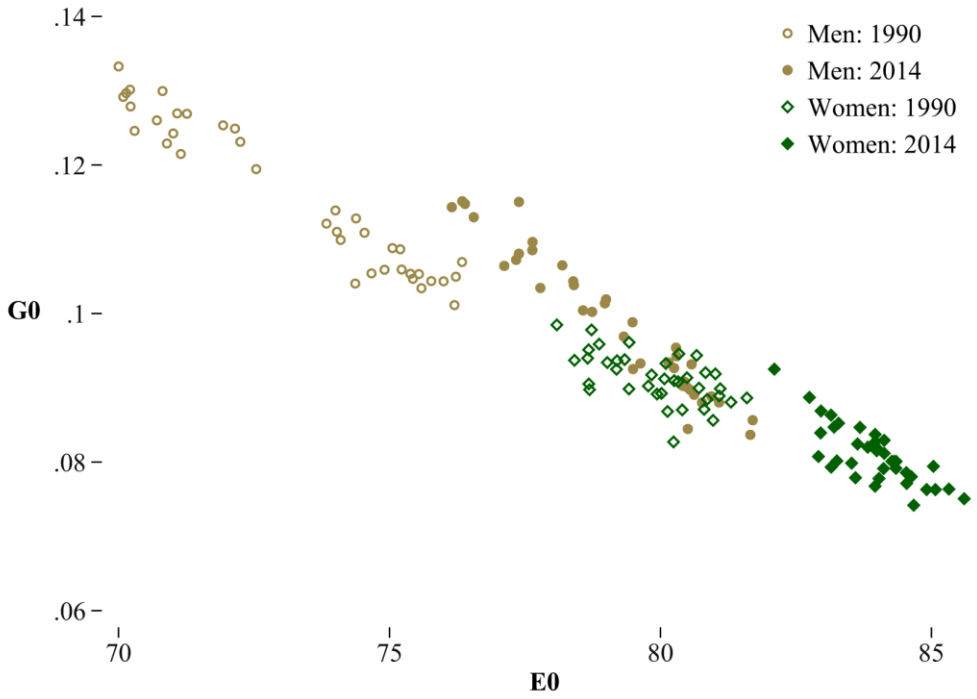
A potentially important aspect of these findings is that there is a 'double disadvantage' of regional inequality in length of life. Not only do some regions, like Kainuu in the east of Finland, have much lower life expectancies than the national average, but they also have greater variation in life expectancies. In essence, there is larger inequality within the regions that exhibit lower life expectancy. This finding is of particular concern given the comparative regional trajectories. As shown in Figure 3, regions appear to exhibit broadly parallel trajectories in terms of both e_0 and G_0. This implies that inequality between regions is persistent. Life expectancy and life-span variation may have improved for men living in Kainuu, but relative to men in other regions of Finland and Sweden they remain in a similarly poor position.

The dynamics of inequality

Given these findings, it seems reasonable to turn our attention to our third and final research question which asks whether there is a relationship between changes in life expectancy and changes in life-span variation at the regional level. In considering this question, we are aiming to expand our knowledge about the dynamics of life-span inequality at the regional level. Regions that have a higher life expectancy tend to have a lower variation in life-span. This is not necessarily surprising. For example, it is well known that life-span variation has fallen as countries have experienced improvements in life expectancy (Shkolnikov, Andreev, and Begun 2003). However, we are not aware of previous research that has studied the link between levels of life expectancy and levels of life-span variation using regions rather than countries, let alone how changes in this variation are related to changes in life expectancy.

In fact, our results suggest there is a very strong linear relationship between the level of regional life expectancy and the level of regional life-span variation (overall R^2=0.89). This is shown in panel 4A of Figure 4. This relationship might be expected, given that recent improvements in Nordic life expectancy have included reductions in mortality at the lower end of the age distribution, which implies a reduction in the variation of ages at death. The gradient of this relationship (between levels) suggests that a five-year improvement in regional life expectancy at birth will be associated with a reduction in life-span inequality of around 0.02 units of G_0.

4A: Relationship between levels of e_0 and G_0 in 1990 versus 2014



4B: Relationship between absolute changes in e_0 and G_0 from 1990 to 2014

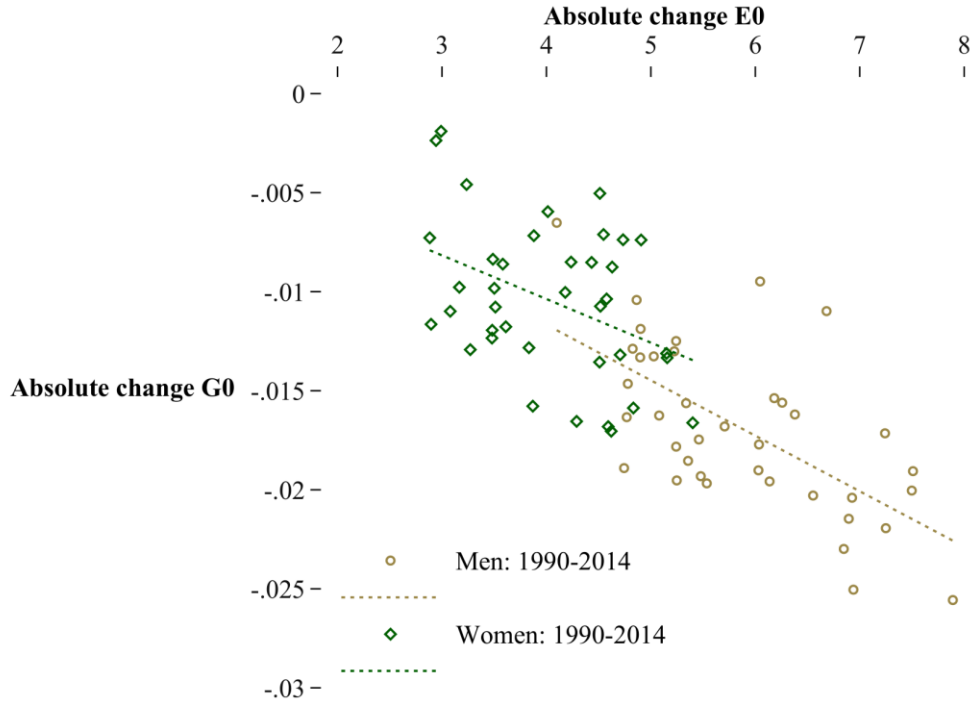


Figure 4 The regional dynamics of life expectancy at birth (e_0) and lifespan variation (G_0)

However, it is important to be cautious about making generalisations about changes over time simply by looking at the relationship between levels. As shown in panel 4B of Figure 4, regional dynamics are subtly different for different groups, including with respect to how they vary for females and males. For males, the percentage change between 1990 and 2014 is substantially larger for both measures, which suggests that males are not necessarily 'falling behind'. In addition, panel 4B shows that the association between change in life expectancy and change in life-span variation is not materially different for women and men at the regional level. It appears that a similar increase in e_0 will lead to similar reduction in G_0 for men as it will for women. This demonstrates similarities between the sexes that have not previously been observed with respect to regional mortality dynamics.

Discussion

This study has shown that regional inequalities in length of life can be extremely persistent, even in a context where life expectancy is high and continually improving. By comparing the regions of Finland and Sweden over a 25-year period, we have not only been able to generate new knowledge about these Nordic countries, but also about the dynamics of regional inequality.

On the one hand, there is reason to be optimistic; life expectancy at birth has improved in all regions, irrespective of either their initial level in 1990 or their relative level ranking in 1990. Similar to observations at the national level, Finnish regions have been catching up with Swedish regions over the whole observation period. Not only have differences between the two countries declined to record-low levels for both men and women – with female life expectancy now virtually the same in Sweden and Finland, and Finnish men only 3 years behind their Swedish counterparts – but the same is also true at the regional level – with almost no difference between regions that have the highest and lowest female life expectancy in Finland and Sweden, and some evidence of a declining difference for men.

At the same time, and accompanying this change in life expectancy, there has also been a reduction in life-span variation in all regions. Indeed, as we have shown, there is a strong relationship between improvements in average life-span and reductions in life-span variation at the regional level. These findings echo previous studies conducted at the cross-national level (Vaupel, Zhang, and van Raalte 2011), which reported strong correlation between life expectancy and life-span variation across 40 countries from 1840 to 2009. The historical record shows that the rise in life expectancy at birth across high-income countries, particularly in the first half of the Twentieth Century, was accompanied by greater equality in life-spans

(Engelman, Canudas-Romo, and Agree 2010). Although our analysis spans a shorter and more recent time frame, our findings suggest that a similar relationship between life expectancy and life-span variation exists at the regional level and that it had been relatively stable over a period of more than two decades.

On the other hand, not all of our evidence about regional trajectories is so encouraging. Although inequality *within* regions – as measured by life-span variation – is decreasing, the last few decades have also seen a highly persistent pattern of inequality *between* regions. The gap in years between regions with the longest-living and shortest-living populations has remained almost constant since 1990. Life expectancy may have improved for men living in the regions with the lowest average male life expectancy – like Kainuu – but relative to men in other regions of Finland or Sweden, they remain in a similarly poor position. We found no evidence that differences between regions are diminishing – for either male or female life expectancy, in both Sweden and Finland – irrespective of the magnitude of changes from 1990-2014, and irrespective of the extent to which Finland has caught up with Sweden (either nationally or regionally).

Although these conclusions may appear to be contradictory when taken at face value, they suggest that evidence about inequality trajectories is highly susceptible, not just to the measure that is used, but also the way that inequality is defined. If we focus on variation *within* regions as a measure of inequality then inequality is declining. Conversely, if we focus on variation *between* regions then inequality appears to be worryingly stagnant, especially in the face of continual improvements in mortality.

Our results imply that inequality between regions is persistent irrespective of the redistributive social policies of these Nordic welfare states. Not only does this finding have important implications for policymakers who are seeking to reduce inequality in length of life, but in the light of broad convergence in national mortality levels it also underlines the need for studies of subnational trajectories in order to identify persistently disadvantaged populations. Moreover, since we find persistent regional inequality in the Nordic context, where welfare provision and social spending are high, then we might expect similarly persistent inequality to exist in other countries.

One encouraging finding is that we did not uncover any diverging trajectories at the regional level. Studies of inequalities by socioeconomic characteristics have shown evidence of divergence in many countries, including Sweden and Finland (e.g. Mackenbach et al. 2003; Huisman et al. 2005). Given that there is considerable socioeconomic variation at the regional

level, it is perhaps surprising that widening socioeconomic inequality does not accompany widening regional inequality.

Of course, it is likely that our research design is unable to identify many underlying patterns of mortality inequality. As noted above, we are limited by our unit of analysis, and results are likely to vary for different spatial units of aggregation. Other limitations of our analysis include our exclusion of Åland in Finland and Gotland in Sweden – both of which may have very different trajectories as compared to mainland regions – as well as the limitations of our time series. It is possible that our regional trajectories would be interpreted differently if they were placed in a longer run (historical) context.

More research is needed to understand the persistence of inequality between regions. At the micro-level, this may take the form of studies that exploit longitudinal register data (or register-like data) to study the role of selective internal migration in determining – or reinforcing – regional variation in mortality. Our results help to lay the foundation for future micro-level analyses, for example by highlighting the regions where improvements in life expectancy are not coupled with improvements in life-span equality.

At the macro-level, research may benefit from making greater efforts to understand the dynamics of regional mortality trajectories. In the final part of our analyses, we have made an initial step in this direction. Our results represent the first examination of the relationship, at the regional level, between changes in life expectancy and changes in life-span variation. They show that there is a very strong relationship between the level of regional life expectancy and the level of regional life-span variation.

Our study of two countries with a strong intertwined history also highlights the potentially important role of persistent historical and cultural factors that help to at least partially explain regional inequalities in mortality. Historically, Finnish regions with the largest share of Swedish speakers had long experienced higher life expectancy and this pattern seems to persist until today. It remains poorly understood how much of this can be attributed to cultural factors or historical ties and how much can be attributed to socioeconomic factors. Future studies may not only try to explain why Finnish men have lagged behind Swedish men, but also why men who live in some regions are persistently experiencing a double-disadvantage with respect to both life-span and life-span inequality, with no sign of either disadvantage weakening over time.

Acknowledgements

We thank the many colleagues who provided helpful comments in the development of this research.

Funding

This work was supported by the Strategic Research Council of the Academy of Finland, decision number 293103, for the research consortium Tackling Inequality in Time of Austerity (TITA), and the Swedish Research Council (Vetenskapsrådet) via the Swedish Initiative for Research on Microdata in the Social and Medical Sciences (SIMSAM), grant 340-2013-5164.

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Appendix Table A1

	Life expectancy								Life-span variation							
	Men				*Women*				*Men*				*Women*			
Regions	*1990*	*rank*	*2014*	*rank*	*1990*	*rank*	*2014*	*rank*	*1990*	*rank*	*2014*	*rank*	*1990*	*rank*	*2014*	*rank*
Sweden:																
Blekinge	75.4	9	79.5	19	81.1	4	84.6	8	0.105	9	0.099	20	0.089	9	0.078	11
Dalarna	75.4	8	80.3	13	80.4	13	83.6	26	0.105	6	0.094	17	0.087	4	0.082	27
Gävleborg	74.1	18	79.3	20	80.1	20	83.0	35	0.110	16	0.097	19	0.091	20	0.084	31
Halland	76.3	1	81.1	3	81.6	1	85.1	3	0.107	13	0.088	5	0.089	8	0.076	3
Jämtland	74.4	16	79.6	17	80.3	15	83.6	27	0.113	20	0.093	15	0.091	18	0.078	9
Jönköping	76.0	4	80.8	5	81.3	2	84.9	5	0.104	4	0.088	4	0.088	6	0.076	4
Kalmar	75.2	10	80.3	15	80.5	12	84.0	20	0.106	12	0.093	13	0.091	21	0.082	24
Kronoberg	76.2	2	81.7	1	81.0	5	85.6	1	0.105	7	0.086	3	0.092	23	0.075	2
Norrbotten	73.8	21	78.7	23	80.3	16	83.1	32	0.112	19	0.100	21	0.091	19	0.079	15
Örebro	75.5	7	80.6	6	80.1	19	83.7	25	0.105	8	0.089	7	0.093	26	0.085	32
Östergötland	75.8	5	80.5	8	80.9	7	84.3	11	0.104	5	0.090	8	0.088	7	0.080	18
Skåne	75.2	11	80.4	11	81.1	3	84.3	14	0.109	14	0.091	11	0.090	14	0.080	20
Södermanland	75.1	12	80.4	12	80.7	10	84.5	9	0.109	15	0.090	10	0.090	15	0.077	7
Stockholm	74.0	20	80.9	4	80.3	14	84.6	7	0.114	21	0.089	6	0.095	33	0.078	10
Uppsala	76.2	3	81.7	2	80.7	11	84.5	10	0.101	1	0.084	1	0.094	32	0.079	12
Värmland	74.9	13	80.2	16	79.9	22	84.1	17	0.106	11	0.093	16	0.089	10	0.079	13
Västerbotten	74.4	17	80.5	9	79.3	27	84.0	23	0.104	3	0.084	2	0.094	30	0.077	6
Västernorrland	74.7	14	79.5	18	79.8	23	82.9	36	0.105	10	0.093	12	0.092	22	0.081	22
Västmanland	74.5	15	80.6	7	81.0	6	84.0	22	0.111	17	0.093	14	0.086	2	0.084	30
Västra Götaland	75.6	6	80.5	10	80.8	8	84.3	13	0.103	2	0.090	9	0.092	24	0.080	19
Central Finland	71.0	29	77.4	32	78.7	33	83.2	31	0.124	26	0.108	31	0.090	12	0.085	33
Central Ostrobothnia	72.5	22	78.6	24	80.2	17	84.7	6	0.119	22	0.100	22	0.083	1	0.074	1
Etelä-Savo	70.0	38	76.6	35	78.9	31	82.7	37	0.133	38	0.113	34	0.096	35	0.089	37
Kainuu	70.2	35	76.4	36	78.7	34	83.3	30	0.130	37	0.115	36	0.091	17	0.080	21
Kanta-Häme	71.3	26	78.2	27	79.8	24	84.0	19	0.127	31	0.106	29	0.090	16	0.082	25
Kymenlaakso	70.7	32	77.4	31	78.7	36	83.3	29	0.126	30	0.115	37	0.094	31	0.085	34
Lapland	70.1	36	77.6	29	78.7	35	83.8	24	0.130	35	0.110	33	0.095	34	0.082	26
North Karelia	70.1	37	77.3	33	78.1	38	82.1	38	0.129	34	0.107	30	0.098	38	0.093	38
North Ostrobothnia	70.9	30	78.4	25	79.2	29	84.3	12	0.123	24	0.104	26	0.092	25	0.079	14
Ostrobothnia	74.0	19	80.3	14	80.8	9	85.3	2	0.111	18	0.095	18	0.087	5	0.076	5
Päijät-Häme	70.2	34	77.1	34	78.4	37	83.1	33	0.128	33	0.106	28	0.094	29	0.086	35
Pirkanmaa	71.1	27	78.4	26	79.4	26	84.0	21	0.121	23	0.104	27	0.090	13	0.083	28
Pohjois-Savo	70.3	33	76.3	37	79.0	30	83.5	28	0.125	27	0.115	38	0.093	27	0.080	17
Satakunta	71.9	25	77.6	30	80.0	21	83.0	34	0.125	29	0.109	32	0.089	11	0.087	36
South Karelia	70.8	31	76.1	38	79.2	28	84.0	18	0.130	36	0.114	35	0.094	28	0.078	8
South Ostrobothnia	72.2	23	77.8	28	80.1	18	85.0	4	0.123	25	0.103	25	0.087	3	0.079	16
Uusimaa	71.1	28	79.0	22	78.7	32	84.1	16	0.127	32	0.101	23	0.098	37	0.081	23
Varsinais-Suomi	72.1	24	79.0	21	79.4	25	84.1	15	0.125	28	0.102	24	0.096	36	0.083	29

Endnotes

[1] Regions in North and East Finland are: Etela-Savo, Pohjois-Savo, North Karelia, Kainuu, Central Ostrobothnia, Northern Ostrobothnia, and Lapland.

[2] Regions in South and West Finland are: Southwest Finland, Kanta-Hame, Paijat-Hame, Kymenlaakso, South Karelia, Central Finland, Southern Ostrobothnia, Ostrobothnia, Satakunta, Pirkanmaa.

[3] These areas are not used officially (e.g. as political or administrative boundaries), but they are widely known in Sweden and their borders fit generally with the regions (i.e. counties) of Sweden, with some small overlaps.

[4] Regions in North Sweden are: Gävleborg, Jämtland, Norbotten, Västerbotten, and Västernorrland.

[5] Regions in Middle Sweden are: Dalarna, Örebro, Södermanland, Stockholm, Uppsala, Värmland, Västmanland.

[6] Regions in South Sweden are: Blekinge, Gotland, Halland, Jönkoping, Kalmar, Kronoberg, Östergötland, Skåne, and Västra Götaland.

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