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

Ben Wilson[1,2] | Sven Drefahl[1,3] | Isaac Sasson[4,5] | Paul M. Henery[6] | Caroline Uggla[1]

[1]Department of Sociology, Stockholm University, Stockholm, Sweden

[2]Department of Methodology, London School of Economics, London, UK

[3]Institute of Environmental Medicine, Karolinska Institute, Solna, Sweden

[4]Department of Sociology and Anthropology, Tel Aviv University, Tel Aviv, Israel

[5]Herczeg Institute on Aging, Tel Aviv University, Tel Aviv, Israel

[6]Faculty of Social Sciences, University of Stirling, Stirling, UK

Correspondence
Ben Wilson, Department of Sociology, Stockholm University, Stockholm, Sweden.
Email: ben.wilson@sociology.su.se

Abstract

An important dimension of inequality in mortality is regional variation. However, studies that investigate regional mortality patterns within and between national and regional borders are rare. We carry out a comparative study of Finland and Sweden: two welfare states that share many attributes, with one exception being their mortality trajectories. Although Finland has risen rapidly in the global life expectancy rankings, Sweden has lost its historical place among the top 10. Using individual-level register data, we study regional trends in life expectancy and lifespan 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 regions in Finland have maintained their mortality advantage over Finnish-speaking regions. Nevertheless, there is some evidence of convergence between the regions of Finland and Sweden.

KEYWORDS
Finland, inequality, life expectancy, lifespan variation, regional, sweden

1 | 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, Orford, Brimblecombe, & Dorling, 2000, p.1055). One of the most prominent dimensions of inequality in European mortality is regional variation, and many studies have shown that there are considerable differences between European regions in their all-cause and cause-specific mortality rates (Eurostat, 2002; Müller-Nordhorn, Binting, Roll, & Willich, 2008; Seaman, Mitchell, Dundas, Leyland, & Popham, 2015; Shaw et al., 2000). Regional differences are of vital importance to the study of mortality inequalities because these differences 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 (Sheehan, Montez, & Sasson, 2018, Montez, Zajacova, & Hayward, 2016).

In this study, we take an innovative approach to conceptualising mortality inequality by focussing on regional trajectories, with respect to both life expectancy and lifespan variation. We go beyond prior studies of health inequalities by comparing and contrasting both of these measures at a regional level, including to examine their interrelationship and how they describe changing patterns of inequality over time. Our study also makes a contribution to the literature by demonstrating that debates about inequality must not only consider the interaction between time and space—in this case, how regional variation has changed over the last few decades—but also how inequality varies according to the way that it is measured. As with the study by McMinn, Dundas, Pell, and Leyland (2020) in this special issue, we show that it is possible for inequality to both increase and decrease over time (albeit in different measures), thereby suggesting that conclusions about inequality may be inaccurate or incomplete unless based on the comparison of multiple measurement approaches.

Researchers have increasingly called for longevity indicators based on averages (mean, median, and modal age at death) to be supplemented with measures of variability in length of life (Le Grand, 1987; OECD, 2007; van Raalte, Sasson, & Martikainen, 2018). National populations can greatly differ with respect to lifespan variation, even at the same levels of life expectancy (Vaupel, Zhang, & van Raalte, 2011). Measures of lifespan variation complement life expectancy and indicate both heterogeneity in underlying population health (Edwards & Tuljapurkar, 2005) and individual uncertainty in the length of life (Edwards, 2013). However, most of what we know about lifespan variation is based on national trends or differences between social groups within or between different nations (Sasson, 2016; van Raalte et al., 2011; Vaupel et al., 2011). Few studies have documented trends in lifespan variation within countries (although, see Sasson, 2016; van Raalte, Martikainen, & Myrskylä, 2014; Brønnum-Hansen, 2017; Permanyer, Spijker, Blanes, & Renteria, 2018; Seaman, Riffe, Leyland, Popham, & van Raalte, 2019), and with the exception of work by Le Grand et al. (Illsley & Le Grand, 1993; Le Grand & Rabin, 1986), few appear to have studied spatial trends in lifespan variation at the regional level.

In contrast to studies of national mortality, the literature on regional (all-cause) mortality consists almost entirely of single-country studies of life expectancy at birth (e.g., Kibele & Janssen, 2013; Langford & Bentham, 1996; Luy, 2004; Marmot et al., 2010; Saarela & Finnäs, 2006; 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 Nomenclature of Territorial Units for Statistics [NUTS2] regions in 15 European countries, see Shaw et al., 2000). As such, there is an absence of studies that examine variation in regional mortality (over time or within regions), 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 health care—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. One benefit of comparing regional mortality in Finland and Sweden is that they have very different national mortality trajectories. For more than 100 years, Sweden has been one of the global leaders in life expectancy (Oeppen & Vaupel, 2002; Vaupel et al., 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, & Modig, 2014). Sweden has lost ground because mortality at higher ages has declined more slowly. By comparison, life expectancy in Finland was much lower at the turn of the 20th century, and Finland was much slower to experience the transition from high to low mortality (Turpeinen, 1979). Yet, the rate of mortality improvement in Finland has been considerable over the last few decades, in particular from the 1970s onwards (Kannisto, Lauritsen, Thatcher, & Vaupel, 1994). As such, life expectancy in the two countries is now much more similar than in the past. In the ranking of European countries, Sweden (in 2010) is only two places higher than Finland (in 2010) in the ranking of female life expectancy (Sweden is 10th and Finland 12th), although the difference is greater for male life expectancy (Sweden is third and Finland 20th, see Marmot, World Health Organisation,, & UCL Institute of Health Equity, 2014, but we note that the life expectancy for some European countries in this ranking is measured prior to 2010). 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 convergence in regional inequality. 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 lifespan inequalities, in Europe or elsewhere. This is an important gap because regional trajectories may differ from national trajectories.

There are some other important differences between Finland and Sweden, including the historical colonisation of Finland by Sweden, 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. 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 comparison is of additional value because it can help to disentangle the role of national and subnational (regional) differences.

Aside from their national mortality trajectories, Sweden and Finland 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 Organisation, & 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).

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 lifespan inequality over a 25-year period from 1990 to 2014. Our main research questions are as follows:

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

2. Have lifespan inequalities within and between regions increased or decreased over time, and does this depend on whether we measure inequality using lifespan variation, rather than differences in life expectancy?

3. What is the relationship, at the regional level, between changes in life expectancy and changes in lifespan variation?

Our aim is not to study the determinants of regional variation. Instead, we seek to understand how regional health inequality—evaluated using several different measures and comparisons—has changed over time. Through the scope of these comparisons, we believe that we are taking an innovative approach to conceptualising regional health inequality. We also consider whether regional trajectories are different for the predominantly Swedish-speaking regions of Finland, as compared with regions in Sweden and the rest of Finland. The answer to this question will help to show the importance of

(historical) population composition in determining regional mortality trajectories.

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 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 regions are consistent over time and are equivalent to Level 3 when using the NUTS developed by the European Union. They are illustrated by Figure 1.

2 | OUR CURRENT UNDERSTANDING OF REGIONAL MORTALITY IN FINLAND

There are two recurrent themes in the Finnish literature on regional variation in mortality. First, clear differences are observed between *North and East Finland*, *South and West Finland*, and *Helsinki-Uusimaa* (i.e., the capital Helsinki and the surrounding region). Regions in the south and west are consistently observed to have lower mortality, whereas mortality rates in North and East Finland[1] are observed to be consistently the highest in the country (e.g., Saarela & Finnäs, 2006, 2010, 2011). Moreover, the mortality of people living in other areas of Finland is higher if they were born in the north or east (Elo, Martikainen, & Myrskylä, 2014; Saarela & Finnäs, 2010, 2011). The persistence of these regional differences 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 & Finnäs, 2006). The reasons for these patterns are less clear, but risky health behaviour is more widespread in the north/east (Elo et al., 2014; Saarela & Finnäs, 2006) and genetic differences may also be part of the explanation (Saarela & Finnäs, 2006, 2010, 2011). Saarela and Finnäs suggest that 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 part of the country (2010). Lastly, the region of Helsinki-Uusimaa 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. Mortality rates in the Helsinki area are disproportionately higher than the other regions in the south-west (Saarela & Finnäs, 2006, 2011).

The other recurrent theme associated with Finish regional mortality is the observed differences between Swedish-speaking and Finnish-speaking Finns. Swedish speakers have lower mortality than Finnish speakers, and this is attributable to a complex mixture of social and heredity factors (Saarela & Finnäs, 2005, 2010, 2011; Sipilä & Martikainen, 2009). Thus, the lower mortality at the regional level may be partly explained by the composition of these two different ethnolinguistic groups. Most of Finland's Swedish-speaking population reside in the south-west of Finland, particularly in Helsinki and the Pohjanmaa regions (often referred to as the "Ostrobothnian" or
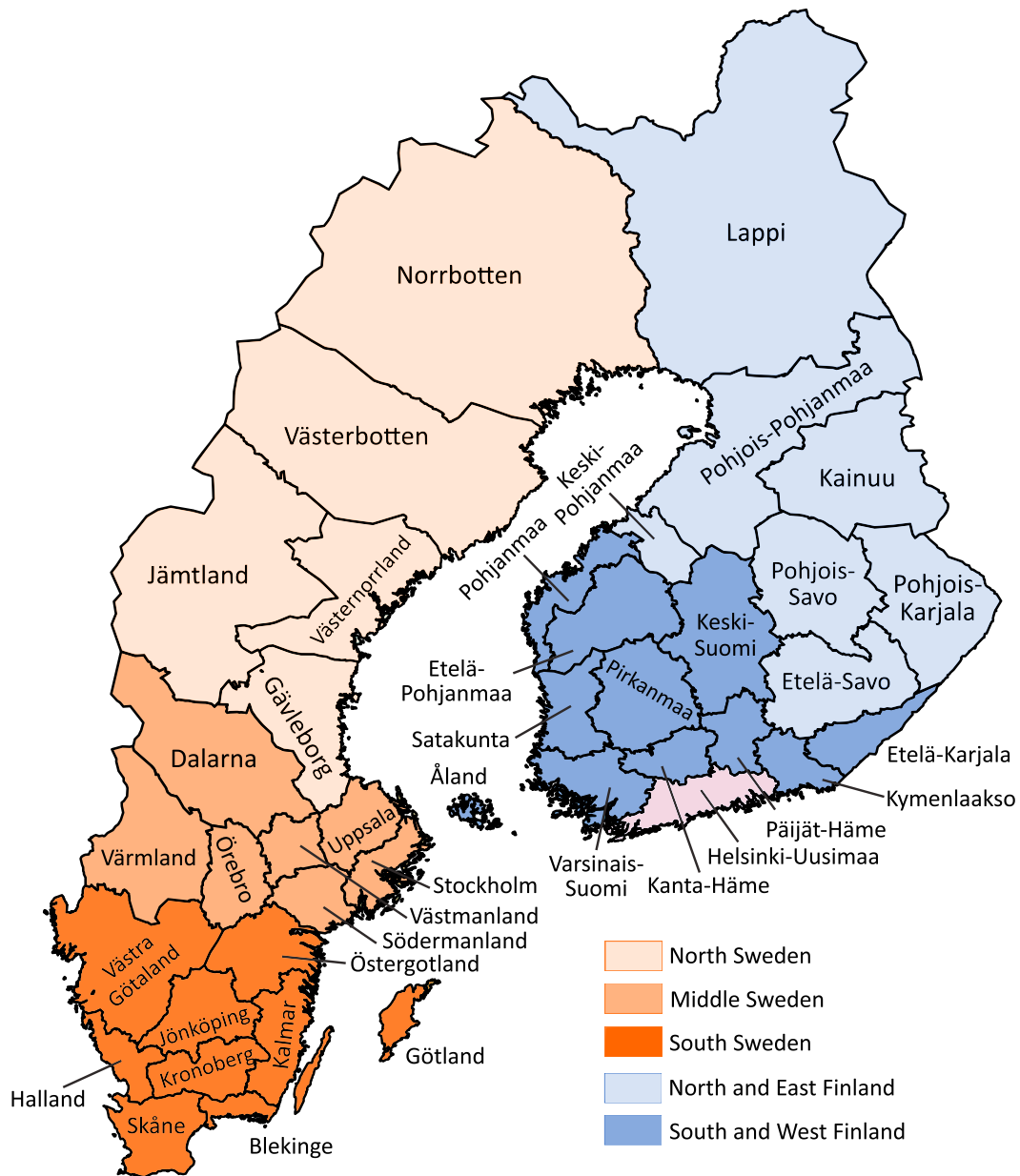
FIGURE 1 A map of the regions of Finland and Sweden

"Bothnian" regions in English, of which there are several, one of which is called "Pohjanmaa" or "Ostrobothnia"). However, Pohjanmaa is the only region of mainland Finland where the Swedish-speaking population is larger than the Finnish-speaking population (the island of Åland is the only other region with a Swedish-speaking majority). 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 & Mielke, 1993). For example, historical studies have shown that patterns of mortality were similar for Stockholm and the (Swedish-speaking) Bothnian parishes of Finland (Turpeinen, 1978; although Stockholm was, and is, far more populated and urban, which may confound this comparison).

3 | OUR CURRENT UNDERSTANDING OF REGIONAL MORTALITY IN SWEDEN

Compared with Finland, there have been fewer studies of regional mortality in Sweden. Much of what is currently known is based on official statistics and publications from Statistics Sweden (SCB). Sweden can be roughly divided into three areas: *North Sweden* (Norrland), *Middle Sweden* (Svealand), and *South Sweden* (Götaland).[2] North Sweden is the largest of the three, whereas the other two are geographically smaller but contain the most highly populated urban areas. There is a general pattern of higher mortality in the north, whereas regions in South Sweden generally have the lowest mortality (Statistics Sweden, 2016). 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 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 and no evidence of a selection of healthy migrants from the North to the South. However, they did find that internal migrants from North to South Sweden had significantly higher mortality, compared with nonmigrants in either the north or the south, if they returned to North Sweden (i.e., evidence of "salmon effects"). On average, the mortality profile of Middle Sweden[3] 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, & Kromhout, 1997). Some regions in Middle Sweden are consistently in the higher quartiles by life expectancy (Stockholm and Uppsala), and some are in the lower quartiles (Örebro, Södermanland, and Västmanland). By comparison, South Sweden[4] has been found to have higher life expectancy than Middle or North Sweden (Sans et al., 1997). It is marginally larger than Middle Sweden by area and is more populated than both North and Middle Sweden, containing two of Sweden's major population centres in Gothenburg and Malmö.

4 | OUR CURRENT UNDERSTANDING OF SEX DIFFERENCES IN NORDIC REGIONAL MORTALITY

Although regional life expectancy data are sometimes used to examine sex differences in mortality (CullenBaiocchi, Eggleston, Loftus, & Fuchs, 2016), studies from the Nordic countries have rarely taken a regional perspective (Oksuzyan, Juel, Vaupel, & Christensen, 2008). 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). Female life expectancy is higher than male life expectancy in all regions of Finland and Sweden (Statistics Finland, 2014; Statistics Sweden, 2016), and the difference in mortality between Swedish-speaking and Finnish-speaking women in Finland is somewhat smaller than between Swedish-speaking and Finnish-speaking men (Sipilä & Martikainen, 2009). One of the contributions of our study is to generate new insights about sex differences in regional mortality for Finland and Sweden.

5 | 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 lifespan 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). We make use of regional data for Finland and Sweden at the level of NUTS3 units (using EUROSTAT definitions for harmonised regional geographical units), often referred to as county-level or regional-level 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 sociocultural 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 (interindividual variability in length of life, a measure of lifespan inequality, see van Raalte et al., 2018). We do this by estimating a Gini coefficient of ages at death (Shkolnikov, Andreev, & Begun, 2003), which we refer to here as G_0. This is the same measure that is used to measure income inequality but applied to ages at death. Numerous measures of inequality have been applied to the study of human lifespans (van Raalte & Caswell, 2013; Wilmoth & Horiuchi, 1999). We chose the Gini coefficient for several reasons. First, the Gini coefficient holds several desirable properties—it is scale invariant, sensitive to transfers, and independent of population size—and can be applied to both complete and abridged life tables without significant loss of accuracy (Shkolnikov et al., 2003). Second, the Gini coefficient has an intuitive interpretation, making it one of the most widely used measures of inequality. It varies from 0 (*perfect equality*) to 1 (*perfect inequality*). The Gini coefficient also has a simple relationship to the Lorenz curve—it is twice the area between the curve and perfect equality. Third, although indices of lifespan variability are highly correlated, the Gini coefficient is more sensitive to changes in the middle of the distribution where most preventable deaths occur (Allison, 1978; van Raalte & Caswell, 2013). In the United States, for example, the recent rise in midlife mortality has resulted in both lower life expectancy and greater lifespan variability (Acciai & Firebaugh, 2019), which the Gini coefficient is well-suited to capture. For these reasons, we do not use alternative ways of measuring lifespan variation, but we note that they are highly correlated with the Gini coefficient (van Raalte & Caswell, 2013). In Appendix A, we

6 | 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 50 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 et al., 2014). This is evident, for example, in the fact that they have an almost identical place in the ranking of female life expectancy for European countries (in a ranking that was published in 2014, Sweden was 10th and Finland 12th, see Marmot, World Health Organisation, & UCL Institute of Health Equity, 2014). As shown in Figure 2, there was almost no difference in life expectancy for women, and only a difference of around 3 years for men, as compared with almost a 10-year difference in 1950.

National data can also be used to calculate trends in the sex difference in mortality. Despite considerable improvements in Finnish life expectancy, including 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 2 years larger in Finland as compared with Sweden, and this remains the case most recently.

6.1 | 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 25 years from 1990 to 2014, all regions have experienced improvements in average lifespan at birth (e_0). Figure 3 shows the average lifespan 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.

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 Pohjanmaa (Ostrobothnia), and for women, it is Pohjanmaa, Keski-Pohjanmaa, and Kanta-Häme. As noted above, Pohjanmaa is the only mainland 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 Pohjanmaa, Varsinais-Suomi, and Helsinki-Uusimaa are the only Finnish regions with better average male life expectancy than Norrbotten, which has the lowest life expectancy of any region in Sweden (see 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 18 regions of Finland are above the median regional life expectancy for the 40 regions of Finland and
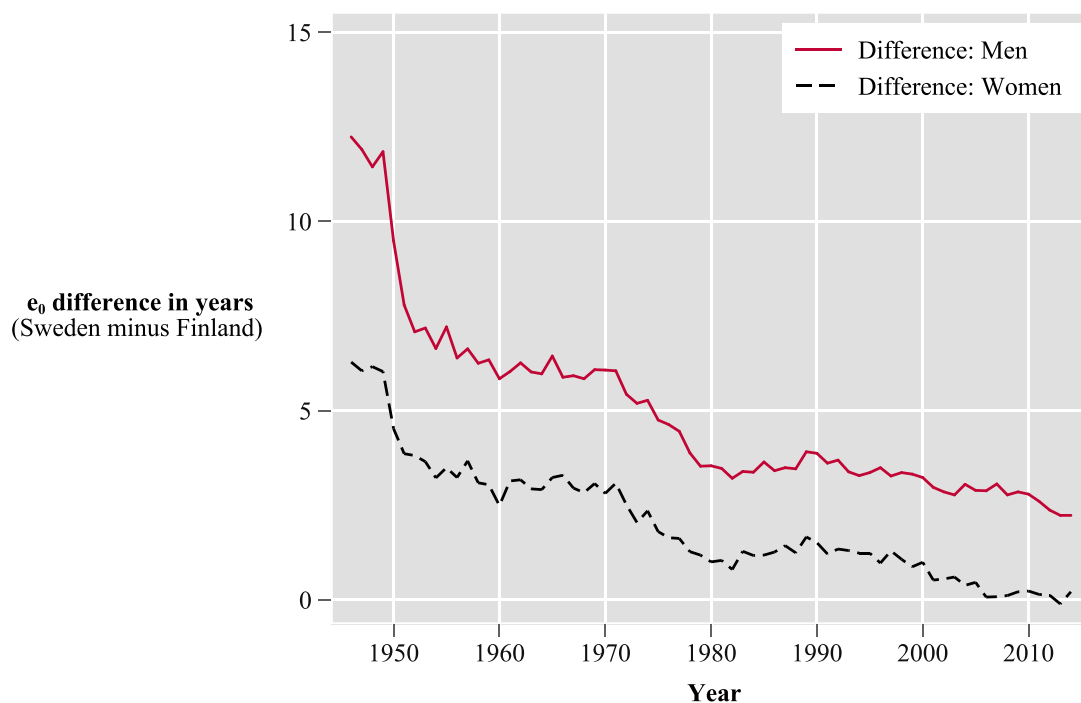
FIGURE 2 Difference (in years) in life expectancy at birth between Sweden and Finland

FIGURE 3 Maps of regional life expectancy at birth for Sweden and Finland

Women

1990   2014

Men

1990   2014
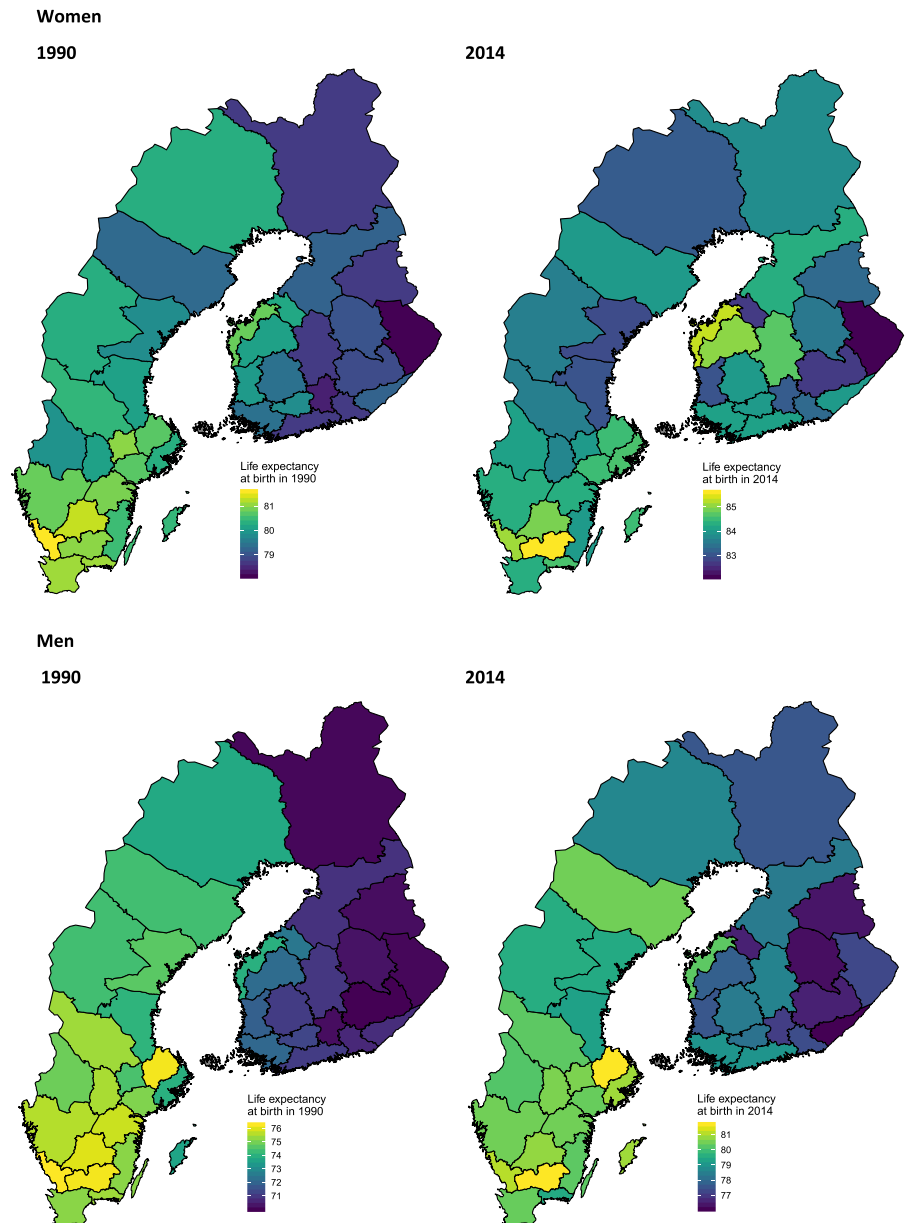
Sweden. Even more notable, perhaps, is the fact that the top-ranking region for female life expectancy in 2012 was a Finnish region—Pohjanmaa (Ostrobothnia)—which remained second overall, behind the Swedish region of Kronoberg, in 2014.

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 they 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 (Pohjanmaa, Varsinais-Suomi, 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 Finnish-speaking regions of

Finland, with the exception of the other Pohjanmaa regions (North, South, and Central Ostrobothnia). Our results, therefore, align with microlevel analysis that shows a consistent longevity advantage for Swedish speakers.

6.2 | Analysis of lifespan variation

Having examined regional trajectories in life expectancy, we turn our attention to our second research question, which asks whether regional inequalities in lifespan 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).
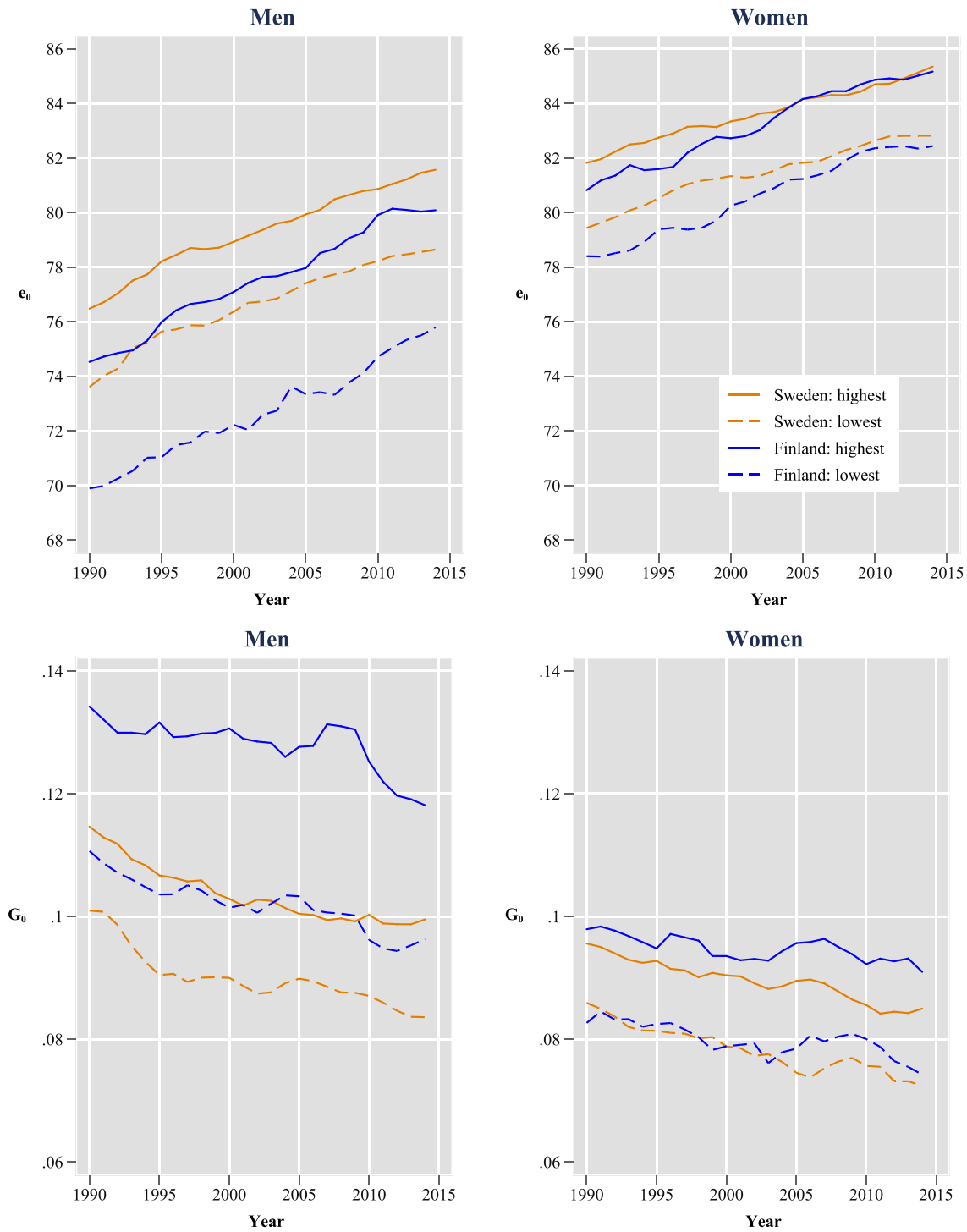
FIGURE 4 Smoothed (3-year moving average) trends in maximum and minimum regional life expectancy (e_0) and lifespan variation (G_0) by sex

Figure 4 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 2 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 4 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

6.3 | The dynamics of inequality
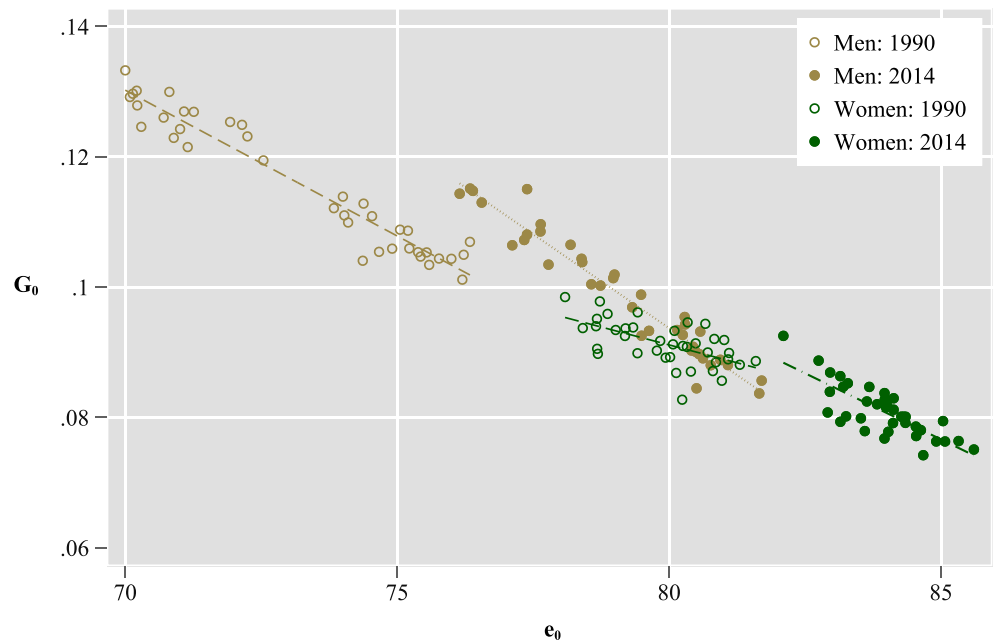
study period, and although there is no sign of this gap widening, there is also no sign of it becoming smaller. For women in both countries and men in Sweden, the gap is around 2 years. For men in Finland, the gap is closer to 4 years. We also note that this evidence of persistence is not driven by our focus on the highest and lowest regions. It remains the same if we calculate the standard deviation of regional mortality (as shown in Table A1), which shows that the variation between regions is similar in 1990 and 2014 (and if anything is slightly increasing).

These results for life expectancy at birth (in the top two panels) can be contrasted with the same analysis for lifespan variation (in the bottom two panels). Although they are a little more erratic year-on-year, the trajectories for regional lifespan variation also show a general pattern of improvement. From 1990–2014, there has been a general decline in lifespan variation (of between 0.01 and 0.03 units), which indicates a reduction in lifespan inequality within regions. At the same time, the gap in each country between the region with the highest and the lowest lifespan 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. Essentially, there is larger inequality within the regions that exhibit lower life expectancy. This finding is notable given the comparative regional trajectories. As shown in Figure 4, regions appear to exhibit broadly parallel trajectories in terms of both e_0 and G_0. Alongside evidence of the similarity in variance between regions in 1990 and 2014 (as shown in Table A1), this implies that inequality between regions is persistent. Life expectancy and lifespan 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.

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 lifespan variation at the regional level. Regions that have a higher life expectancy tend to have a lower variation in lifespan. This is not necessarily surprising. It is well known that lifespan variation has fallen as countries have experienced improvements in life expectancy (Shkolnikov et al., 2003). However, we are not aware of previous research that has studied the link between levels of life expectancy and levels of lifespan 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 that there is a very strong negative (linear) relationship between the level of regional life expectancy and the level of regional lifespan variation (overall $R^2 = 0.89$). This is shown in Figure 5, which also shows how the association between regional e_0 and G_0 has changed over time (separately for women and men). A negative relationship might be expected because 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 5-year improvement in regional life expectancy at birth will be associated with a reduction in lifespan inequality of around 0.02 units of G_0. At the same time, Figure 5 suggests that regional changes in G_0 do not necessarily occur to the same extent as changes in e_0. By 2014, regions with the highest male mortality—that is, the Finnish regions—had reached levels of e_0 well above those of Swedish regions in 1990 but had broadly the same levels of G_0 (as Swedish regions in 1990). This means that regions which are slower to reach particular levels of life expectancy may do so with higher levels of lifespan variation.

In order to understand these regional mortality dynamics in more detail, we calculate absolute and relative changes for women and men

(a)

(b)
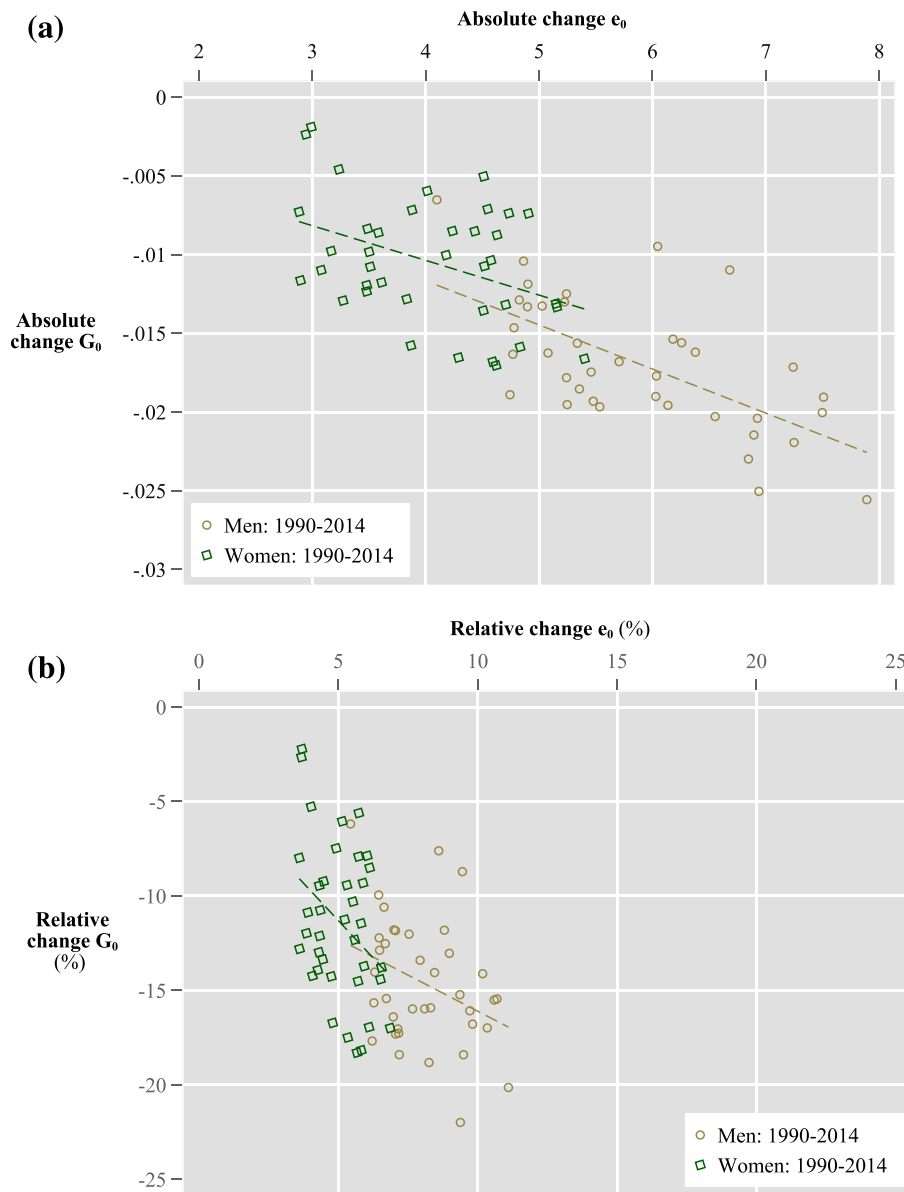
FIGURE 6 The relationship between (a) absolute and (b) relative changes in life expectancy at birth (e_0) and lifespan variation (G_0) from 1990 to 2014

between 1990 and 2014. As shown in Figure 6, regional dynamics are subtly different 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." At the same time, the association between change in life expectancy and change in lifespan variation is not materially different for women and men at the regional level. None of the regions experienced an increasing lifespan variation over the two time periods, and it appears that a similar increase in e_0 will lead to a 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.

7 | 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 or their relative ranking in 1990. In parallel with national trends, Finnish regions have been catching up with Swedish regions. 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 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. Accompanying this change in life expectancy, there has also been a reduction in lifespan variation in all regions. Indeed, as we have shown, there is a strong relationship between improvements in average lifespan and

reductions in lifespan variation at the regional level. These findings echo previous cross-national research (Vaupel et al., 2011), which finds a strong correlation between life expectancy and lifespan 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 20th century, was accompanied by greater equality in lifespans (Engelman, Canudas-Romo, & Agree, 2010). Although our analysis spans a shorter and more recent time frame, our findings suggest that a similar relationship between life expectancy and lifespan 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 our evidence about regional trajectories is so encouraging. Although inequality *within* regions is decreasing—as measured by lifespan variation—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—like Kainuu—with the lowest average male life expectancy, 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). We note that this aligns with recently published studies of Scotland, which also show that spatial inequalities in lifespan variation are persistent over time (Seaman et al., 2019; Seaman, Riffe, & Caswell, 2019). Unlike Scotland, it appears that there is less evidence of a widening gap in Sweden and Finland, although this may depend on the measure that is used (the studies are not directly comparable, but Table A1 shows that standard deviations of regional mortality are slightly higher in 2014 than in 1990).

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 (i.e., between individuals within regions), 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 why inequality between regions remains so entrenched. Moreover, because we find persistent regional inequality in the Nordic context, where welfare provision and social spending are high, we might expect similarly persistent inequality to exist in other countries.

One encouraging result is that we did not find evidence of diverging trajectories at the regional level. Studies of socioeconomic inequalities have shown evidence of divergence in many countries, including Sweden and Finland (e.g., Huisman et al., 2005; Mackenbach et al., 2003). Given that there is considerable socioeconomic variation at the regional level, it is perhaps surprising that widening socioeconomic inequality does not accompany widening health inequality. However, this does not exclude the possibility that (increasing) socioeconomic inequality is what helps regional health inequalities to persist, such that policies to diminish socioeconomic inequality—including between regions—may also help to reduce regional health inequalities. Further research is required to examine the veracity of such a claim.

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. It is also important to note that the existence of inequality with respect to mortality will not necessarily be accompanied by inequality in other measures of health. As shown in several other studies in this special issue, there is considerable evidence of a health-mortality paradox, at least for some groups of immigrants and their descendants (Cezard, Finney, Marshall, & Kulu, 2020; Wallace & Darlington-Pollock, 2020). The 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 microlevel, 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 (such as the study by Darlington-Pollock & Norman, 2020 in this special issue). If internal migrants have different levels of health and mortality, and some regions receive (or send) more internal migrants, then migration may help to explain the existence or persistence of regional inequality. Future research may contribute by examining this question (e.g., building upon the evidence of selective return migration in Sweden, see Andersson & Drefahl, 2016). Our results also help to lay the foundation for future microlevel analyses, for example, by highlighting regions where improvements in life expectancy are not coupled with improvements in lifespan equality.

At the macrolevel, 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 lifespan variation. They show that there is a very strong relationship between the level of regional life expectancy and the level of regional lifespan 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. Previous research on Finland suggests it is not only sociodemographic factors that determine regional mortality but also region of birth and ethnicity (parental and grandparental background, see Saarela & Finnäs, 2010). However, similar research has yet to be carried out from a cross-national perspective. 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 lifespan and lifespan inequality, with no sign of either disadvantage weakening over time.

CONFLICTS OF INTEREST

We are not aware of any financial interest or benefit that has arisen from the direct applications of our research.

DATA AVAILABILITY STATEMENT

These data use population register data for Finland and Sweden that are available via an application process from the government statistical agencies of the respective countries.

ORCID

Ben Wilson https://orcid.org/0000-0003-4274-617X
Sven Drefahl https://orcid.org/0000-0003-4533-7558
Isaac Sasson https://orcid.org/0000-0001-7033-9497
Paul M. Henery https://orcid.org/0000-0003-0380-738X
Caroline Uggla https://orcid.org/0000-0003-1639-3307

NOTES

[1] Regions in North and East Finland are Etelä-Savo, Pohjois-Savo, Pohjois-Karjala, Kainuu, Keski-Pohjanmaa, Pohjois-Pohjanmaa, and Lappi.

[2] 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.

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

[4] Regions in South Sweden are Blekinge, Gotland, Halland, Jönköping, Kalmar, Kronoberg, Östergötland, Skåne, and Västra Götaland.

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APPENDIX A.

TABLE A1 Life expectancy (e₀) and lifespan variation (G₀) for men and women in Finland and Sweden by region, 1990 and 2014

| Regions | Life expectancy | | | | | | | | Lifespan variation | | | | | | | |
| | Men | | | | Women | | | | Men | | | | Women | | | |
	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
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
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
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
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
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
SD	0.7		0.7		0.6		0.7		0.003		0.004		0.002		0.003	

(Continues)

TABLE A1 (Continued)

Regions	Life expectancy								Lifespan variation							
	Men				Women				Men				Women			
	1990	Rank	2014	Rank	1990	Rank	2014	Rank	1990	Rank	2014	Rank	1990	Rank	2014	Rank
Finland																
Etelä-Karjala	70.8	31	76.1	38	79.2	28	84.0	18	0.130	36	0.114	35	0.094	28	0.078	8
Etelä-Pohjanmaa	72.2	23	77.8	28	80.1	18	85.0	4	0.123	25	0.103	25	0.087	3	0.079	16
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
Helsinki-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
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
Keski-Pohjanmaa	72.5	22	78.6	24	80.2	17	84.7	6	0.119	22	0.100	22	0.083	1	0.074	1
Keski-Suomi	71.0	29	77.4	32	78.7	33	83.2	31	0.124	26	0.108	31	0.090	12	0.085	33
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
Lappi	70.1	36	77.6	29	78.7	35	83.8	24	0.130	35	0.110	33	0.095	34	0.082	26
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
Pohjanmaa	74.0	19	80.3	14	80.8	9	85.3	2	0.111	18	0.095	18	0.087	5	0.076	5
Pohjois-Karjala	70.1	37	77.3	33	78.1	38	82.1	38	0.129	34	0.107	30	0.098	38	0.093	38
Pohjois-Pohjanmaa	70.9	30	78.4	25	79.2	29	84.3	12	0.123	24	0.104	26	0.092	25	0.079	14
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
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
SD	1.0		1.1		0.7		0.8		0.005		0.006		0.004		0.005	