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Do Vanguard Populations Pave the Way towards Higher Life Expectancy for Other Population Groups?

The mechanisms of increasing human longevity have been elucidated in part by observing vanguard groups whose mortality has decreased more quickly than the rest of the population. In the case of the three Nordic countries (Finland, Norway and Sweden) studied by Domantas JASILIONIS, Vladimir SHKOLNIKOV, Evgueni ANDREEV, Dmitri JDANOV, Denny VÅGERÖ, France MESLÉ *and* Jacques VALLIN, *this pioneer group is made up of married, highly educated individuals. Using individual census-linked mortality data, the authors compare trends in life expectancy and mortality by cause of death between this vanguard group and the rest of the population from the 1970s to the 1990s. The study shows that besides simply following directions shown by the vanguard groups, non-vanguard groups have their own pathways to low mortality which are related to specific determinants of mortality changes.*

Overall progress in reducing mortality during the second half of the twentieth century went together with unprecedented growth in mortality inequalities between countries (Caselli et al., 2002; McMichael et al., 2004; Moser et al., 2005). This can be interpreted in the framework of health transition theory (Frenk et al., 1991; Meslé and Vallin, 2002, 2006) enriched by the assumption that each major epidemiological development initially gives rise to divergence in mortality trends (Vallin and Meslé, 2004). Even developed countries differ greatly in their degree of advancement in the health transition; while some countries are still fighting against cardiovascular diseases, others

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have successfully completed this stage and are entering a new phase of transition where life expectancy gains will increasingly depend on progress in combating cancers, mental disorders and other age-related degenerative diseases (Vallin, 2005). One of the most illustrative examples of this divergence is the emergence of an east-west mortality divide in Europe following the cardiovascular revolution. While western Europe was striding ahead in this area, central and especially eastern Europe have yet to emerge from a long-term health crisis that led to stagnation and even decline in life expectancy in the 1970s (Vallin and Meslé, 2004; Meslé, 2004). In this respect, some advanced countries may be considered as pioneers or vanguards, opening a path towards lower mortality, while others, unable to profit from these innovations, lag behind (Oeppen and Vaupel 2002; Vaupel 2003). Vanguard countries benefit sooner from progress because of more favourable contextual factors, including their capacity to disseminate and implement medical advances across the whole population.

During the last few decades, similar divergence in mortality trends has been observed at the sub-population level (Valkonen, 2001; Mackenbach et al., 2003; Shkolnikov et al., 2006, 2012). In Finland, mortality decreased continuously over the 1970s-1990s, but unevenly across different social and marital status groups (Martikainen et al., 2005). In particular, mortality reductions were slower in groups with higher starting levels of mortality, and faster in groups with the lowest starting levels. These trends have led to a widening of relative mortality differences by socioeconomic status and by marital status (Valkonen, 2001; Martikainen et al., 2005; Murphy et al., 2007).

Long-term increases in mortality differences between population groups in developed countries can also be interpreted using the same convergence-divergence framework within the health transition theory (Vallin and Meslé, 2005). As is the case at country level, the advantaged population groups also benefit first from new favourable conditions such as access to the most advanced medical technologies or improved living conditions. It takes time for the rest of the population to catch up with more advanced population groups in terms of resistance to disease and death. For example, Valkonen (1997) showed that it was not until the 1990s that manual workers reached the life expectancy already enjoyed by non-manual workers in the 1960s.

Research devoted to mortality differentials focuses primarily on the magnitude of these differences or on the unfavourable mortality situation of the disadvantaged groups. This is understandable because mortality inequalities are a matter of ethical concern and a prime target of health policies (Peter and Evans, 2001; Venkatapuram, 2011). At the same time, the populations with the lowest mortality receive much less attention, even though the best practice (or vanguard) groups within national populations are establishing the new frontiers of survival and longevity that will eventually be reached by others (Desplanques, 1973; Martelin, 1996; Valkonen, 1997). Could vanguard groups be considered as predictors of the future mortality of other groups and of entire populations?

Previous research using the same data found striking increases in absolute and relative mortality disparities by education in Finland, Norway, and Sweden (Shkolnikov et al., 2012). The current study extends previously reported evidence in two directions. First, we use two dimensions of sociodemographic status to construct the two population groups under study. The vanguard group is defined as the group of highly educated married people, while the non-vanguard group comprises all the rest of the population (non-married and/or with low or medium education). Second, this study provides new evidence about the changes in mortality differences by large groups of causes of death, enabling us to better understand possible determinants of mortality differentials within each country. The main aim of the study is to identify the extent to which the non-vanguard populations might follow the mortality trajectories of the vanguard group in different age ranges and for major causes of death. For this purpose, we systematically analyse trends in age- and cause-specific mortality in the vanguard groups and remaining (non-vanguard) populations from the early 1970s to the early 1990s. It is particularly interesting to look at this period because it covers the three first decades of the cardiovascular revolution.

I. Data and methods

Census-linked mortality data were provided by the statistical offices of Finland, Norway, and Sweden. For Finland, census-based information about education and official marital status was linked with the register information about deaths during the following five calendar years after the 1970, 1975, 1980, 1985, 1990 and 1995 censuses. For Norway, this same linkage was performed, but using data from just three censuses, in 1970, 1980 and 1990. Data were thus available for three five-year periods: 1971-1975, 1981-1985, and 1991-1995. Finally, only the censuses of 1970 and 1990 were available for Sweden, so the data series for this country cover only two five-year periods (1971-1975 and 1991-1995).

The total and group-specific population exposures were calculated from the census population, accounting for deaths and migrations by level of education and marital status obtained from the population register. The data for Sweden include 1.72 million deaths and 74.8 million person-years at ages 40 and older. The corresponding data for Finland and Norway include, respectively, 1.31 and 1.18 million deaths, and 60.5 and 51.2 million person-years of exposure.

The range of ages is constrained to age 40 and above because the census-based educational level and marital status are assumed to be fixed during the five-year periods following each census. This constraint thus helps to avoid potential problems related to more frequent changes in the educational and marital status of individuals below this age. Changes in overall and age-specific mortality were assessed by means of life expectancy at age 40 and probabilities of dying within age ranges 40-64 years, 65-74 years, and 75-84 years. The contributions of the major causes of deaths to the overall changes in life expectancy at age 40 (between 1971-1975 and 1991-1995) were measured using a method of decomposition of aggregated demographic measures (Andreev et al., 2002). Group- and cause-specific standardized death rates were calculated using a direct standardization method based on the WHO European standard population.

Definition of vanguard and non-vanguard population groups

In this study, vanguard groups are defined as married people with high education. They are contrasted with the rest of the population. Education and marital status are two major health determinants. High education refers to completed university or non-university higher education (confirmed by a diploma). The high education category is comparable across the three countries which have maintained similar educational systems. Education is often referred to as a human capital gained early in life, which is associated with abilities to make rational choices and acquire social, psychological, and economic resources (Evans et al., 1994; Mirowsky and Ross, 2003). Using broad educational groups instead of any other socioeconomic variables allows us to rely on a well-defined characteristic that remains stable from early adulthood. Using occupational status as a variable is problematic as it is often difficult to classify the status of some specific population groups such as homemakers or disabled people (Valkonen et al., 1993). Another methodological challenge related to this variable concerns the choice of occupational classification system, which may substantially influence the results (Kunst et al., 1998).

Marital status is one of the dimensions of social capital, which is related to the specifics of relationships between individuals (social networks) (Putnam, 2000). It has been suggested that the protective effect of marriage stems from the better social support and psychosocial conditions provided by marriage (Hu and Goldman, 1990; Hughes and Waite, 2002). Due to data constraints,[(1)] the group of highly educated married people does not include cohabiting males and females with high education. In any case, such an exclusion is not very problematic since some prior studies suggest that cohabiting males and females show notably higher mortality risks than officially married males and females (Koskinen et al., 2007). This disadvantage of cohabitation has been attributed to specific determinants such as a higher prevalence of risky health behaviors and stress, as well as lower social support (Koskinen et al., 2007; Liu and Reczek, 2012).

It is a theoretical possibility that the remaining (non-vanguard) populations might eventually benefit from the same advantages as highly educated and married people (e.g. through health education programmes or increasing social support). However, this will only be the case if the observed life expectancy

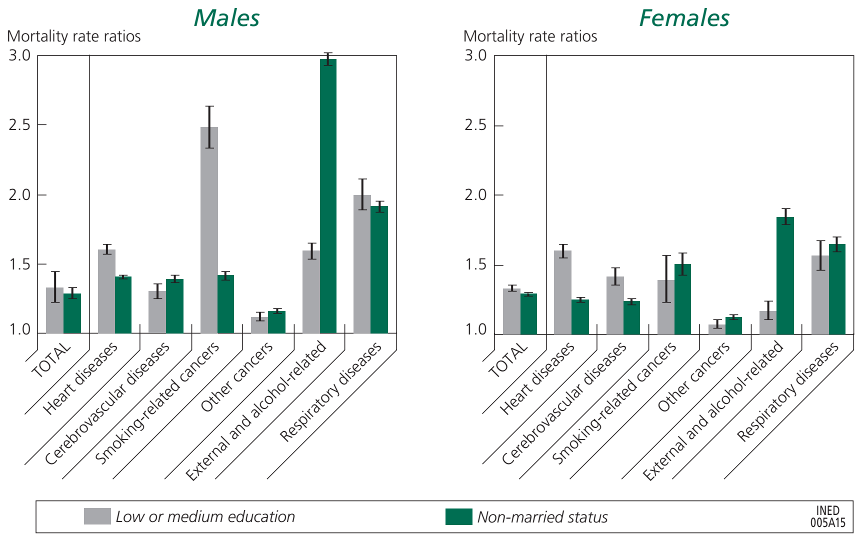
(1) Our analysis relies on census-linked mortality data, for which only official marital status was available.

advantage of both highly educated and married people with respect to lower educated and non-married people is not an artefact due to the selection of healthier individuals into both high education and marriage (Hu and Goldman, 1990; Fu and Goldman, 1996). But if it is an artefact, then mortality convergence between the vanguard and non-vanguard groups remains highly unlikely unless there is a notable change in health selection mechanisms.

The findings on the role of health selection in explaining life expectancy advantages of highly educated and married people are inconsistent. The majority of studies have found only a moderate direct effect of health selection on mortality risk, or no effect at all (Fox et al., 1982; Marmot, 1999, 2004; Cornman et al., 2003; Manzoli et al., 2007). Fu and Goldman (1996) found that only unhealthy behaviours (alcohol consumption and drug abuse) and some physical characteristics (obesity and short stature) have a significant impact on the timing of first marriages, while the presence of medical diseases or functional limitations have only small or non-significant impacts. In the case of socioeconomic differentials, it has also been suggested that class position itself is more important to the risk of poor health than poor health to class position (Vågerö and Illsley, 1995; Marmot, 2004).

Education and marital status influence mortality in different ways. Figure 1 illustrates the differences in the effects of education and marital status on mortality from a few major causes of death in Finland. For example, education

Figure 1. Ratios of cause-specific mortality rates by education and marital status at ages 40 years and over, Finland, 1971-2000 (Poisson regression)



Notes: Outcomes of Poisson regression models. The models were run separately for each sex and include age, period, education, and marital status. High education is the reference group for the education variable, and married is the reference group for marital status.

Source: Authors' computations based on unpublished data from Statistics Finland.

has a stronger effect on the risk of smoking-related male (but not female) mortality than marital status. A similar relationship can be also observed for mortality due to heart diseases. At the same time, being married is more effective than high education in reducing the risk of dying from alcohol-related causes of death. These differences may indicate that marriage is especially protective with respect to alcohol, but less so for controlling male smoking (possibly considered by spouses as being less disruptive for family life and less harmful in general than alcohol).

The vast majority of studies report the separate (one-dimensional) effects of education and marital status on mortality. However, there are important independent effects of interactions between education and marital status. For example, married men and women benefit not only from their own education, but also from the educational status of their spouses. There is evidence showing

Table 1. Relative sizes (%) of the vanguard, educational, and marital status groups in Finland, Sweden, and Norway, 1971-1975 and 1991-1995

	Finland		Norway		Sweden	
	1971-1975	1991-1995	1971-1975	1991-1995	1971-1975	1991-1995
Males						
Education						
High	5.9	11.7	8.4	19.3	6.0	16.5
Medium	13.7	32.2	21.2	44.1	16.8	26.3
Low	80.4	56.1	70.4	36.6	77.1	57.2
Marital status						
Married	80.8	72.0	78.6	72.6	76.9	68.5
Never-married	11.3	13.9	12.3	11.2	13.3	15.6
Divorced	3.2	10.2	3.0	10.6	4.4	11.3
Widowed	4.7	3.9	6.1	5.6	5.4	4.6
Vanguard group	5.4	9.9	7.5	15.4	5.5	12.7
Females						
Education						
High	4.0	9.1	3.4	12.8	3.6	15.3
Medium	12.2	29.3	15.1	41.5	10.9	23.5
Low	83.8	61.7	81.5	45.7	85.5	61.2
Marital status						
Married	59.8	57.6	64.8	59.8	66.6	59.1
Never-married	14.2	11.4	12.5	7.8	11.7	10.1
Divorced	4.8	11.3	3.6	10.4	5.3	12.8
Widowed	21.2	19.7	19.0	22.0	16.4	17.9
Vanguard group	2.3	5.9	2.1	8.6	2.5	10.2

Note: Vanguard group: married with high education.
Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

that the wife's education has an even stronger impact on the husband's mortality risk than his own education (Jaffe et al., 2006; Torssander and Erikson, 2009).

Table 1 documents changes in the proportions of highly educated people, married people, and people who are both highly educated and married (vanguard group) in the populations of Finland, Sweden, and Norway. Between 1971-1975 and 1991-1995, the relative size of the vanguard group increased notably in all three countries. The increases were more pronounced among women, proportionally far fewer in this group in 1971-1975. These increases in relative size varied from a low of 1.8 times among the Finnish men to a high of 4.2 times for Norwegian women. In all countries, the relative size of the vanguard group increased due to improvements in education while the size of the married group decreased (Table 1). The fastest growth (four-fold increase) of both the vanguard and high education groups was observed among Norwegian and Swedish women. Despite this rapid growth, the proportions of vanguard women remained considerably below the levels of men in all three countries (Table 1). The growth of vanguard groups in the three countries suggests that they may have become much less selective in terms of health. In that case, the difference between vanguard and non-vanguard populations should decrease. If not, it would indicate that any observed increase in the difference is understated.

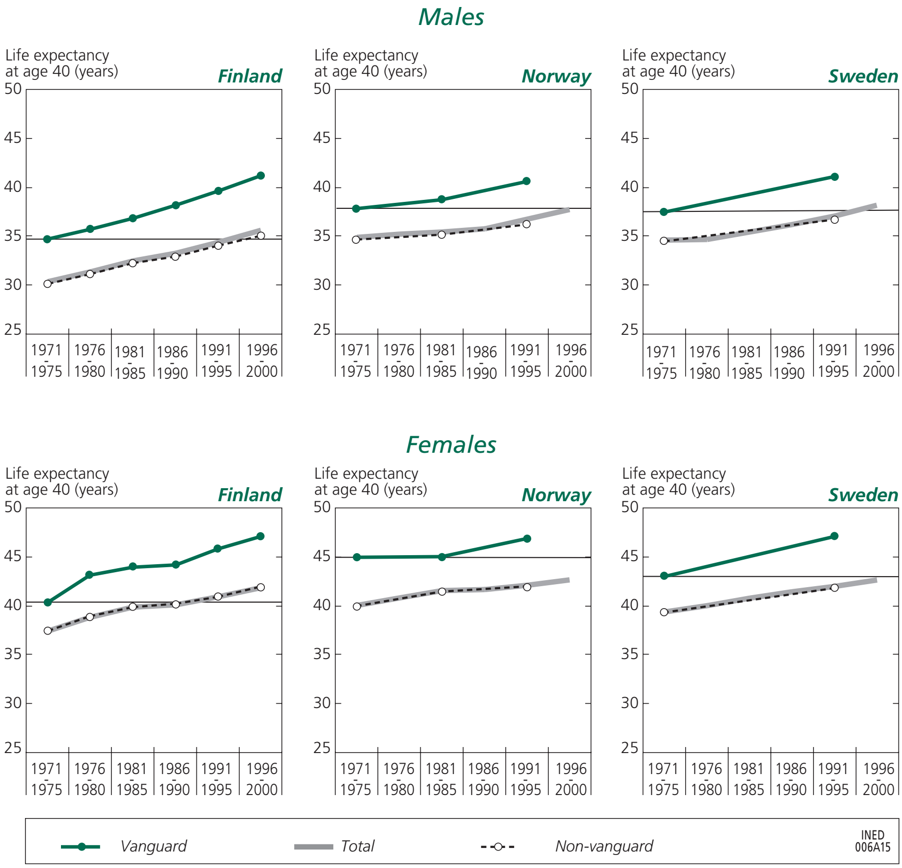
II. Results

No signs of convergence in life expectancy

Before presenting detailed analyses of the mortality trends by age and major causes of death, we first focus on general trends in life expectancy at age 40 for the total, vanguard, and non-vanguard populations in Finland, Norway, and Sweden over the period 1971-1995.

Figure 2 shows that the three countries experienced notable rises in life expectancy over the two decades. However, there were important country-specific differences in the magnitude of life expectancy gains. For both sexes, increases in overall life expectancy were greatest in Finland (4.1 years for men and 3.5 years for women) and lowest in Norway where they were barely half as large (1.9 years for men and 2.1 years for women). The gains in Sweden fell between these two extremes (2.5 years for men and 2.7 years for women). It should also be noted that in the early 1970s, life expectancy in Finland was much lower than in the other two countries, and that Norway was the leader in longevity. Despite faster longevity improvements and convergence towards the levels of the other two countries, Finland continued to lag behind in terms of life expectancy. For male life expectancy, Sweden was initially in the intermediate position, but overtook Norway in the second half of the 1980s. Female life expectancy in Sweden was slightly below the corresponding indicators for Norway throughout the period.

Figure 2. Trends in life expectancy at age 40 for the vanguard groups, non-vanguard groups and total populations of Finland, Norway, and Sweden, 1971-1975 to 1991-1995



Notes: Vanguard group: married with high education. The horizontal line indicates the initial life expectancy levels (in 1971-1975) of the vanguard groups in each of the three countries. Data for Finland and total populations of Sweden and Norway are for 1971-1975 to 1996-2000.

Sources: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

Despite the improvement in life expectancy at age 40 over the two decades of observation, there were no signs of substantial convergence between vanguard and non-vanguard populations in any of the three countries (Figure 2). In all three, the life expectancy gains were more pronounced in the vanguard group than in the non-vanguard group. The most significant improvements were observed among the Finnish vanguard population (5.0 and 5.5 years for males and females, respectively), whereas the smallest gains were observed among the Norwegian non-vanguard males. Interestingly, the Norwegian vanguard females, who had the highest life expectancy at the beginning, experienced almost no improvement between 1971-1975 and 1981-1985. It is also important to note that only Finnish non-vanguard males and females in the 1990s managed to catch up with the initial life expectancy levels of the vanguard group of 1971-1975 (Figure 2).

Differences in the speed of life expectancy improvements have led to notable increases in the life expectancy gap between the vanguard and non-vanguard groups. Among males, this gap increased significantly in all three countries. The biggest differences were observed in Finland for both 1971-1975 (4.5 years) and 1991-1995 (5.6 years). Swedish males, who had the smallest gap at the beginning, also experienced the biggest increase in the gap (from 3.0 to 4.4 years). Among females, the initial life expectancy gap was widest in Norway (5.0 years) and narrowest in Finland (3.0 years). Over two decades of observation, the differences increased notably in Sweden and Finland, reaching the same levels as in Norway (around 5 years).

No signs of convergence in mortality within different age ranges

Figure 3 summarizes the trends in probabilities of dying within different age ranges (40-64 years, 65-74 years, and 75-84 years). It is immediately clear that despite some important cross-country variations, there were no signs of convergence between vanguard and non-vanguard groups within any of the three age ranges. Furthermore, the data for Finland suggest that mortality trends continued to diverge until the second half of the 1990s at least.

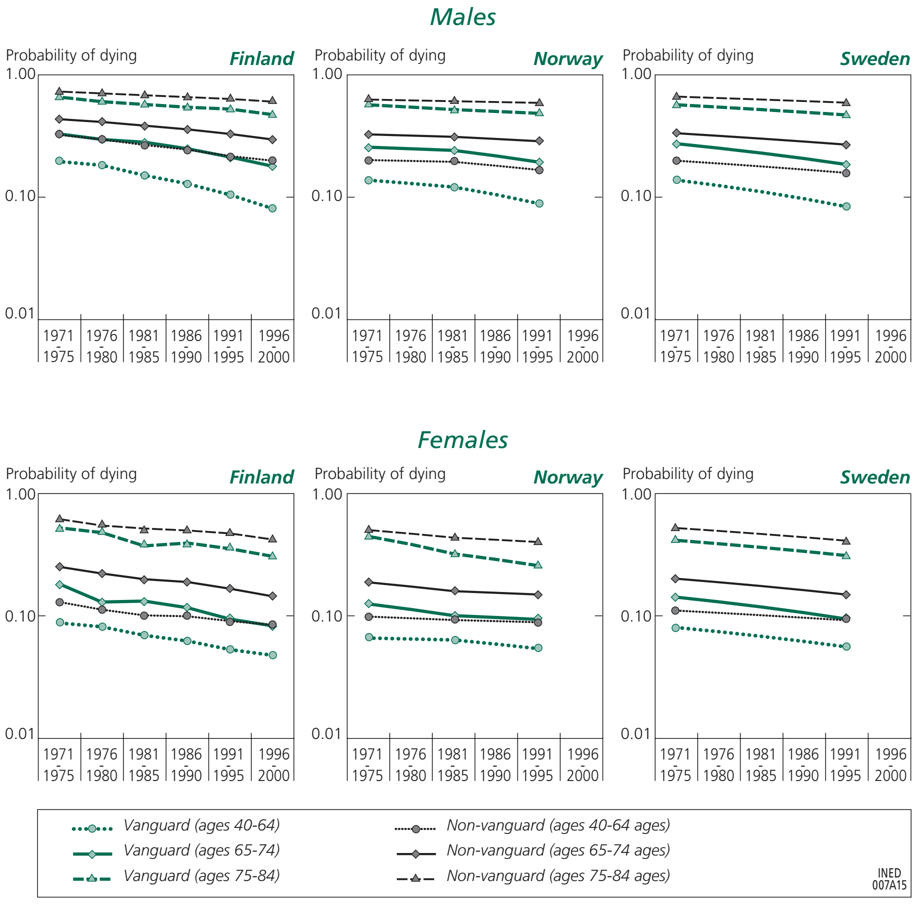
The biggest differences in probabilities of dying between the vanguard and non-vanguard groups can be observed among males aged 40-64 years. Between 1971-1975 and 1991-1995, the gap within this age range increased notably in all countries. Among females in this age group, growth in the difference between probabilities of dying was less pronounced.

Within the other two age groups, the range of the divergence in trends of probabilities of dying also differs by sex. Despite some increase over the two decades, male mortality differences within the age ranges 65-74 and 75-84 years remained less pronounced than within the 40-64 age group. Among females, the mortality differences at age range 65-74 remained almost as large as within the younger 40-64 age range. The most striking divergence in the trends of age-specific female probabilities of dying between the vanguard and non-vanguard groups was observed in the oldest age group in Norway (Figure 3).

Differential contributions of causes of death to changes

Figure 4 reveals numerous similarities and few differences in the patterns of cause-specific contributions to the overall changes in life expectancy at age 40 in vanguard and non-vanguard groups between 1971-1975 and 1991-1995. In all three countries, life expectancy gains in both groups were mainly achieved thanks to the successful reduction of cardiovascular mortality (Figure 4). Differences in the magnitude of contributions of this cause of death also mainly explain the differences in the overall life expectancy gains between vanguard and non-vanguard groups, especially for males. The contributions

Figure 3. Trends in probabilities of dying between the exact ages 40-64, 65-74, 75-84 for vanguard and non-vanguard groups of Finland, Norway, and Sweden, 1971-1975 to 1991-1995 (1996-2000 for Finland) (log scale)

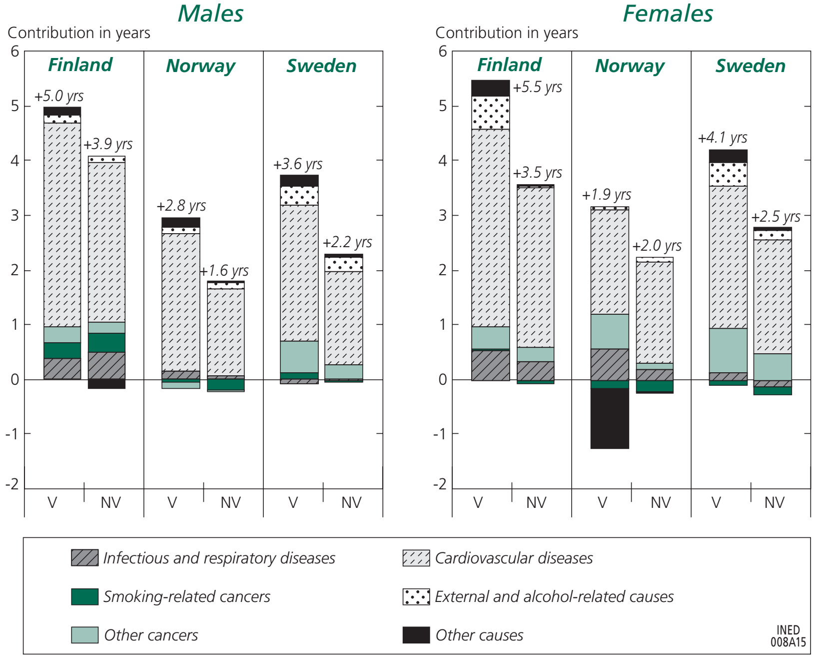


Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000.
Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

of the decreases in cardiovascular mortality ranged from 2.5 years for the Norwegian and Swedish vanguard males to 3.7 years for the Finnish vanguard males. Among non-vanguard males, the corresponding contributions were smaller: 1.6 years in Norway, 1.7 years in Sweden, and 2.9 years in Finland. With the exception of Norwegian females, similar differences can be observed for Swedish and Finnish females (Figure 4).

Other causes of death had a much smaller impact on divergence in life expectancy changes. Life expectancy gains due to reductions in cancer mortality (other than smoking-related cancers) were greater for the vanguard group for females in all three countries, and for vanguard males in Sweden. By contrast, in Norway, the contributions of neoplasms were negative for both male groups

Figure 4. Cause components of the total changes in life expectancy at age 40 in vanguard and non-vanguard populations in Finland, Norway, and Sweden from 1971-1975 to 1991-1995



Notes: V = vanguard group; NV = non-vanguard group.
Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

and for non-vanguard females. Smoking-related cancers produced almost equally important positive contributions in Finland, whereas the impact of these causes was much smaller or even negative in the other two countries (Figure 4).

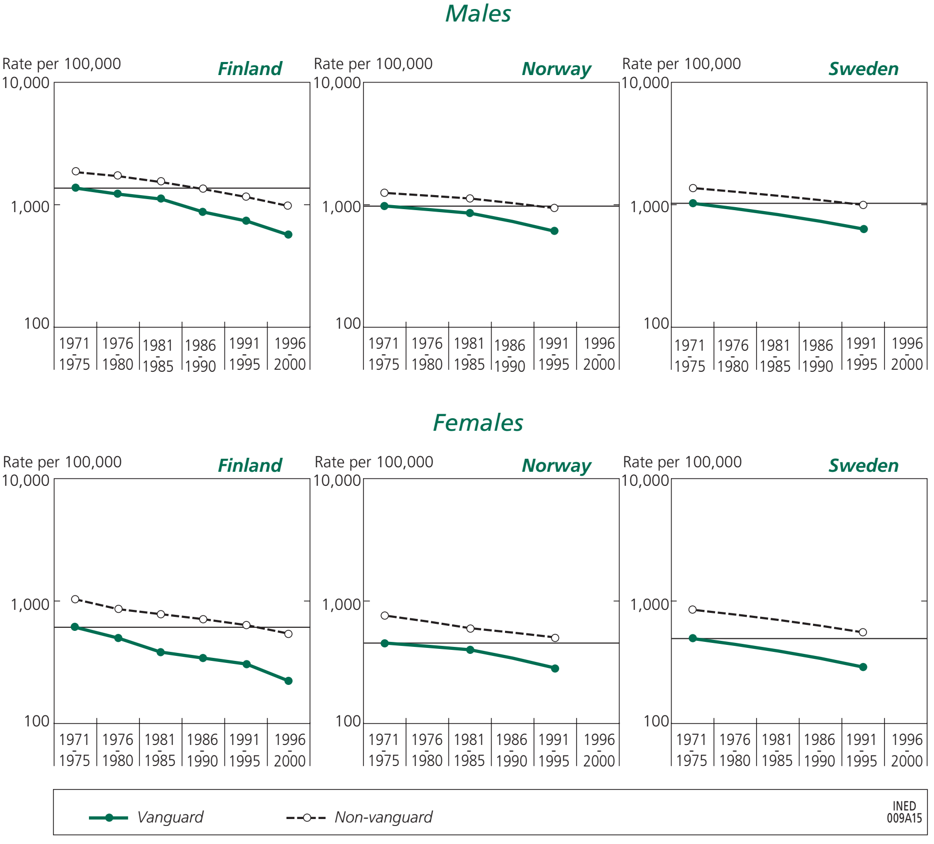
The impact of other causes varies from country to country. The combined group of external and alcohol-related causes of death(2) played a more important role for changes in life expectancy for males in Sweden, and for females in Finland and Sweden. In particular, the bigger contributions of this cause explain greater life expectancy gains among the vanguard females in Finland and Sweden. The infectious and respiratory system diseases made important contributions only in Finland (both sexes) and Norway (females). The only visible difference in the magnitude of the gains can be observed between vanguard and non-vanguard females in Norway. Finally, a substantial negative contribution of all other causes of death counterbalanced a large part of the life expectancy gains in the female vanguard group in Norway (Figure 4).

(2) The numbers of female deaths due to alcohol-related causes were too small to get meaningful results from decomposition analysis. Alcohol-related deaths were therefore included in a bigger group of causes combining alcohol-related and external causes of death. Changes in male mortality due to alcohol-related and external causes of death in vanguard and non-vanguard groups are discussed in the next section.

Growing divergence in major causes of death

Figures 5-10 show standardized death rates by major causes of death. They suggest that for most causes of death, the mortality gap between the vanguard and non-vanguard groups increased or at least remained at the same initial level.

Figure 5. Trends in age-standardized death rates for cardiovascular system diseases in vanguard and non-vanguard groups in Finland, Norway, and Sweden, 1971-1975 to 1991-1995 (log scale)



Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000. The horizontal line indicates the initial mortality levels (in 1971-1975) of the vanguard groups in each of the three countries.

Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

The most interesting trends to observe are those of mortality due to cardiovascular system diseases, which made the greatest contribution to life expectancy changes in all three countries. Figure 5 shows that cardiovascular mortality decreased in the vanguard groups at least as fast as in the non-vanguard groups, and sometimes even faster. The only exception concerns vanguard and non-vanguard females in Norway who show temporary convergence between 1971-1975 and 1981-1985. As a result of the diverging trends, the mortality differential between the two groups increased from a ratio of 1.3-1.4 to a ratio 1.5-1.7 for males and from 1.7 to 1.8-2.5 for females. The most dramatic widening of the mortality gap was observed for Finnish females, with an increase in the ratio from 1.7 to 2.5. It was not until 1986-90 (Finland), or even until 1991-1995 (Sweden and Norway) that non-vanguard males surpassed the initial mortality level of the vanguard males, while non-vanguard females in Norway and Sweden had still not reached the initial level of vanguard females by the end of the period covered.

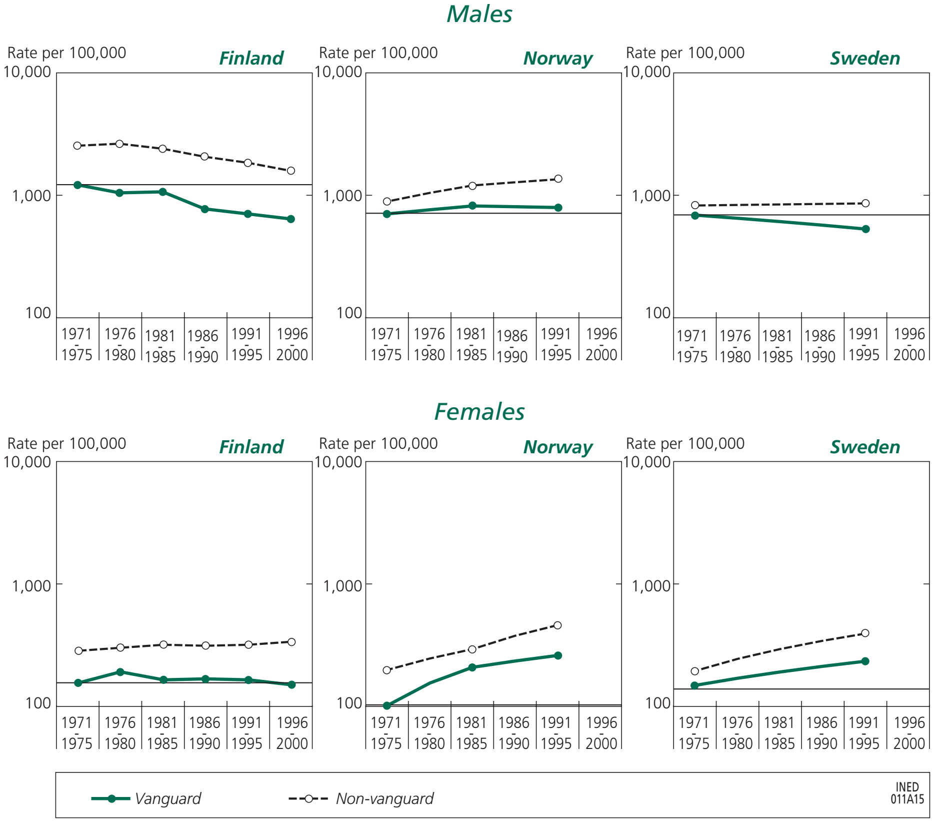
Figure 6. Trends in age-standardized death rates for all non smoking-related cancers in vanguard and non-vanguard groups in Finland, Norway, and Sweden, 1971-1975 to 1991-1995 (log scale)

Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000. The horizontal line indicates the initial mortality levels (in 1971-1975) of the vanguard groups in each of the three countries.

Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

For cancer mortality (excluding smoking-related cancers) likewise, there is no clear sign of convergence (Figure 6). The only exception concerns a temporary slowdown of improvements in the vanguard group in Finland which led to a narrowing of the gap in the early 1980s. However, this short-lived convergence was replaced by a stagnation or widening of the gap in the subsequent periods. The most striking trend occurred in Norway, where cancer mortality increased among both vanguard and non-vanguard males. Since the worsening was more pronounced in the non-vanguard group, the gap between the two groups also increased. Among Norwegian females, cancer mortality increased only in the non-vanguard group, whereas vanguard females saw a decreasing trend (with a slowdown between 1981-1985 and 1991-1995). Finally,

Figure 7. Trends in age-standardized death rates for smoking-related cancers in vanguard and non-vanguard groups in Finland, Norway, and Sweden, 1971-1975 to 1991-1995 (log scale)



Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000. The horizontal line indicates the initial mortality levels (in 1971-1975) of the vanguard groups in each of the three countries.

Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

cancer mortality decreased notably in both groups in Sweden, albeit faster in the vanguard group.

It is also interesting to look at the important group of smoking-related cancers. Once again, there are no signs of convergence (Figure 7). Moreover, smoking-related cancers decreased only among Finnish males (both groups) and among Swedish vanguard males. In Finland, this progress was more consistent and slightly faster in the vanguard group. Strikingly, mortality from smoking-related cancers increased for both vanguard and non-vanguard female groups in Sweden and Norway. This worsening was much more pronounced for non-vanguard groups. The only exception concerns Norwegian females between 1971-1975 and 1981-1985, for whom mortality increased faster in the vanguard group.

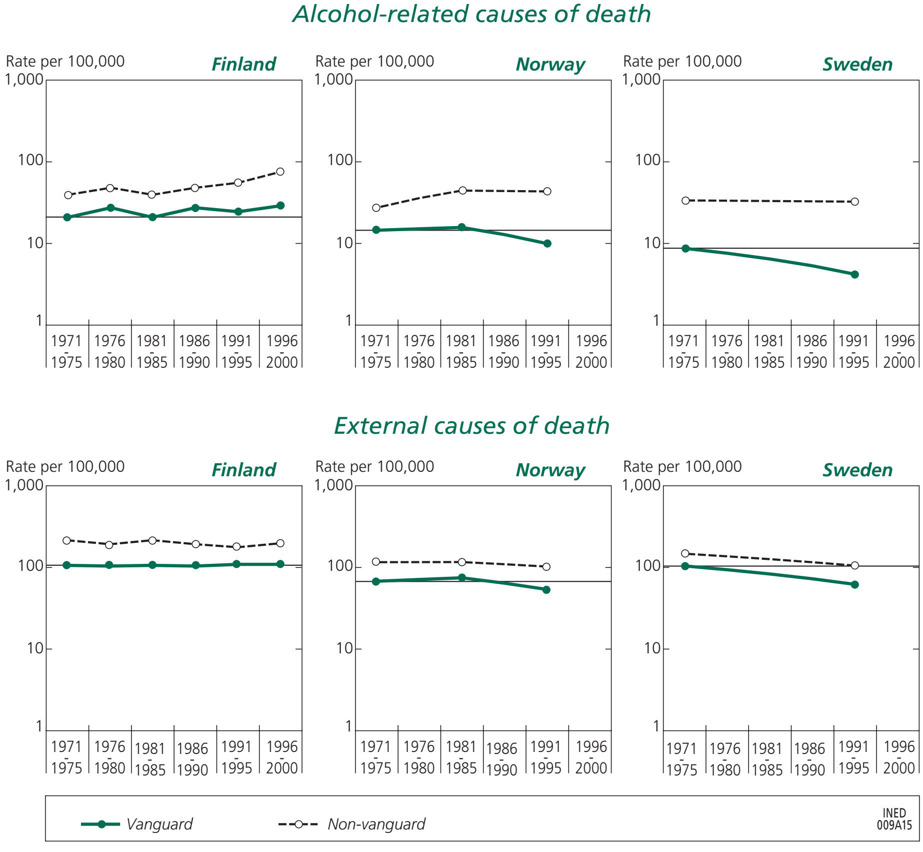
Figure 8. Trends in age-standardized death rates for infectious and respiratory diseases in vanguard and non-vanguard groups in Finland, Norway, and Sweden, 1971-1975 to 1991-1995 (log scale)

Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000. The horizontal line indicates the initial mortality levels (in 1971-1975) of the vanguard groups in each of the three countries.

Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

Figure 8 points to inconsistent mortality trends for the group of infectious and respiratory system diseases. It can be concluded, however, that mortality differences between the two groups increased in all three countries, but in completely different ways. In Finland, both vanguard and non-vanguard males show parallel and systematic declines in mortality throughout the period, but with a flattening trend for the non-vanguard group at the end of the period covered. Among females, progress was very rapid for the vanguard group between 1971-1975 and 1981-1985, but less so for the non-vanguard group. During the period 1981-1985 to 1996-2000, these trends were replaced by a stagnation (non-vanguard group) or even growth (vanguard group) in mortality. In Norway, the group-specific mortality trends also differ by sex. Among males,

Figure 9. Male age-standardized death rates for external and alcohol-related causes for vanguard and non-vanguard groups in Finland, Norway, and Sweden, 1971-1975 to 1991-1995 (log scale)



Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000. The horizontal line indicates the initial mortality levels (in 1971-1975) of the vanguard groups in each of the three countries.

Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

the only visible improvement occurred in the vanguard group between 1971-1975 and 1981-1985, while mortality in the non-vanguard group remained at about the initial level. From then on, mortality stagnated in both groups. For females, the mortality gap increased notably. Finally, Sweden showed parallel worsening trends for both groups and no increase in the mortality gap among males. Among females, mortality increase was observed only in non-vanguard females, whereas vanguard females showed a stagnating trend, leading to a widening of the intergroup mortality gap.

Alcohol-related and external causes of death among males provide a very illustrative example of the diverging trends between the vanguard and non-vanguard groups (Figure 9). In Finland, alcohol-related mortality increased in both groups. However, the deterioration was much more pronounced in the non-vanguard group. In Norway and Sweden, it decreased in the vanguard group and increased or remained at the same level in non-vanguard group. Consequently, in these two countries the mortality differentials widened remarkably (from ratios of 1.9 and 3.9, respectively, in 1971-1975 to ratios of 4.3 and 7.7, respectively, in 1991-1995).

There was no comparable widening of the mortality gradient for external causes of death. Due to the lack of progress in the vanguard group in Finland and Norway, there was even a narrowing of mortality differences between 1971-1975 and 1981-1985. However, the trends started diverging again in the subsequent periods. Sweden showed progress in reducing mortality from external causes in both groups, with a faster pace in the vanguard group.

Finally, the only signs of convergence are for mortality due to all other remaining causes of death among Norwegian females (Figure 10). This can be explained by opposite trends (increase in vanguard group and decrease in non-vanguard group) in this group of causes of death between 1971-1975 and 1981-1985. As a result, the mortality gap decreased and remained at the same level until the end of the period covered. A similar convergence in mortality trends also occurred among Finnish females but it was replaced by subsequent divergence after 1986-90. At the same time, due to more rapid progress in the vanguard group and an absence of improvement in the non-vanguard group, the inter-group differences increased for both sexes in Sweden. Last, Finnish males showed the most inconsistent trends. The parallel rapid decreases in mortality in both groups in the 1970s were replaced by divergence in the early 1980s due to mortality stagnation in the non-vanguard group. However, from then on, the two groups evolved in a parallel manner. In both groups, the simultaneous increase in mortality in 1986-1990 was followed by stagnation during the subsequent periods. It should be noted, however, that this group of causes of death is very heterogeneous. It includes both degenerative nervous system diseases, more prevalent in the vanguard group, and digestive system diseases, more frequent in the non-vanguard group. This may also explain the very contradictory trends and contributions of this group of causes of death in Norway.

Figure 10. Age-standardized death rates for all other causes, vanguard and non-vanguard groups in Finland, Norway, and Sweden, 1971-1975 to 1991-1995 (log scale)

Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000. The horizontal line indicates the initial life expectancy levels (in 1971-1975) of the vanguard groups in each of the three countries.

Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway.

III. Summary and discussion

This study examined time trends in life expectancy at age 40, and cause-specific mortality in the vanguard groups and remaining (non-vanguard) populations in Finland, Norway, and Sweden from the 1970s to the 1990s. It looked at the role played by age- and cause-specific mortality trends. We used high quality census-linked data which are comparable across the countries, enabling us to calculate uniform estimates of group-specific mortality.

The analyses also have some limitations, however. First, there were fewer time points for Sweden and Norway so we were not able to follow precisely all peculiarities of the time trends in these countries. Second, there were several changes in the classification systems of causes of death during the period covered. This may have affected the comparability of the data for different periods and produced some unexpected results, such as the surprising trends and contributions of mortality due to all other causes of death among the Norwegian vanguard females. However, since we used only broad groups of causes of death, the effect of changes in classification or coding practices is not likely to change our conclusions about the directions of the trends. Third, due to data constraints we were not able to consider cohabiting couples as a separate group and they are excluded from the vanguard population. This limitation should be taken into account when interpreting results, as the non-vanguard population includes several very diverse sub-groups. For example, it has been shown that cohabiting males have substantially lower risk of dying than males living alone (divorced, widowed or never-married), but a higher risk than married males (Koskinen et al. 2007).

The study suggests that there were no signs of convergence in life expectancy at age 40 between vanguard and non-vanguard groups, even in egalitarian Nordic countries. On the contrary, divergence occurred in all age ranges. The life expectancy advantages of the vanguard group can be explained above all by greater progress in reducing mortality due to cardiovascular system diseases, especially for males. However, other causes have also contributed to divergence and their roles differ by sex and country. In particular, vanguard females benefited more from reductions in mortality from non smoking-related cancers (all countries), external and alcohol-related causes of death (Finland and Sweden), and infectious and respiratory diseases (all countries). Strikingly, smoking-related mortality played a negative role for both the vanguard and non-vanguard groups in Sweden and Norway.

The analyses of time trends in cause-specific mortality in the three countries found no systematic convergence in group-specific mortality trends. Moreover, mortality gaps increased for most groups of causes of death under study. We also observed that considerable lapses of time were needed for the non-vanguard group to catch up with the initial mortality levels of the vanguard group. These time lags reflect the fact that the sub-populations in the three countries are still in the phase of divergence in terms of completing the second stage of the health transition, corresponding to the so-called "cardiovascular revolution" – the decisive change in the treatment and prevention of cardiovascular system diseases observed in the majority of Western countries since the 1970s (Vallin and Meslé, 2004). One additional factor of divergence is a persisting (or even increasing) burden of "man-made" diseases (alcohol- and smoking-related causes of death, traffic accidents, suicides, and homicides) which are directly related to human activity and barely affected by advances in medicine (Meslé and Vallin, 1993).

It can be concluded that rather than simply following in the footsteps of the vanguard groups, the non-vanguard groups are taking separate routes to low mortality which are related to specific determinants of mortality changes. This is especially noticeable for non-vanguard mortality from certain causes of death showing adverse trends or periods of stagnation. Furthermore, unexpected worsening trends in cancer mortality for both vanguard and non-vanguard groups in Norway also suggest that each country has its own pathways and contextual factors shaping the ongoing health transition. Our findings illustrate that changes in the course of the health transition can be very complex, even within a single country. The timing and speed of mortality reductions may vary dramatically across population groups, and some groups may enter new stages of epidemiological development without completing the previous stages (Vallin and Meslé, 2004). In this context, the convergence of the non-vanguard populations towards mortality levels of the vanguards is only possible when both groups benefit equally from new medical knowledge and from new means to control and eliminate the social and environmental conditions that lead to disease. The convergence will also occur if the vanguard group, having fully exploited all possible avenues for extending life expectancy, is confronted by causes of death for which no remedy is available, thus reaching the biological limits for further mortality reduction (Vallin, 2005). However, as has been seen in the past, it is more likely that new successes in combatting these causes of death will eventually lead to another divergence-convergence phase (Vallin and Meslé, 2005).

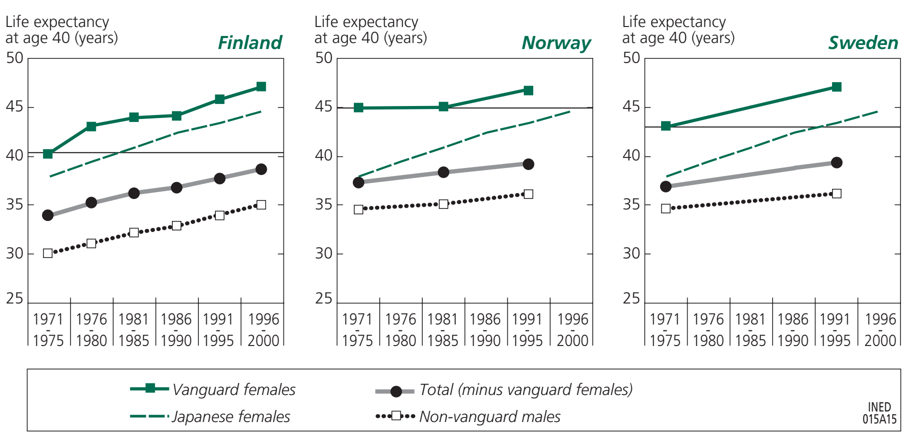
The observed mortality divergences for causes of death that are avoidable (through access to effective medical care and inter-sectorial prevention policies), such as tobacco-related cancers, alcohol-related diseases or external causes of death, suggest that even in egalitarian societies, inequalities in access to medical advances, in lifestyles and in social and environmental conditions are still very significant. Mortality inequalities thus persist, despite a strengthening of pro-equitable social, economic, and health policies in all three countries during the period under study. However, these policies focusing primarily on material aspects of inequality may have been ineffective because they were not radical enough to eradicate material inequalities, but also because mortality inequalities became more sensitive to non-material factors such as psychosocial wellbeing, ability to control one's own life, or other personal characteristics operating at the individual level (Mackenbach, 2012).

At least part of the observed mortality gap between vanguard and non-vanguard groups should be attributed to the effect of direct and indirect health selection. However, as the relative sizes of vanguard groups in the three countries increased notably, health selection might play a lesser role. This is related to the fact that the share of highly educated people increased sharply whereas the share of officially married people decreased only modestly, remaining very high (above 58%) in all three countries under study. It is also unlikely that the shrinking non-vanguard group became more selective due to an inverse selection of individuals with poor health. This group was still very large (more than 80% of the total popualtion) at the end of the period covered. The overall impact of health selection may be further diminished in the future by introducing appropriate policies acting at early stages of life or even before birth (Marmot, 2010).

It is also possible to assume that the true vanguard populations are the female vanguard populations in these countries (Figure 11). Here too, we observe a divergence in life expectancy trends between the vanguard females and remaining population groups (non-vanguard females and total male populations) in Finland and Sweden. The trends are less consistent for Norway, where a temporary convergence is observed between 1971-1975 and 1981-1985. In 1991-1995, the life expectancy advantage of the vanguard females with respect to the remaining populations in the three countries reached the level of about 8 years. If compared to the laggard population group (non-vanguard males), this advantage becomes even more striking (above 10 years in 1991-1995), and there were no signs of convergence between these two extreme groups. It is also interesting to compare vanguard females with total Japanese females, who have been world longevity leaders for several decades (Oeppen and Vaupel, 2002). This gives an idea of the potential for further life expectancy improvement in this group. Although Japanese females reduced their disadvantage with respect to Swedish and Norwegian vanguard females, the life expectancy gap remained notable (about 4 years in 1991-1995).

The study using age- and cause-specific mortality data for vanguard groups also adds a new dimension to the discussion about the upper limits of life

Figure 11. Trends in life expectancy at age 40 for vanguard females, rest of the population (both sexes) and non-vanguard males in Finland, Norway and Sweden, and for Japanese females, 1971-1975 to 1996-2000



Notes: Vanguard group: married with high education. Data for Finland are for 1971-1975 to 1996-2000. The horizontal line indicates the initial mortality levels (in 1971-1975) of the vanguard females.

Source: Authors' computations based on unpublished data from Statistics Finland, Statistics Sweden, and Statistics Norway. Data for Japanese females are from the Human Mortality Database (2012).

expectancy. With the exception of Norwegian females for the period between 1971-1975 and 1981-1985, we did not find any evidence of a slowdown or stagnation of mortality in the vanguard group within any of the age ranges. The same consistent improvements were observed for mortality due to cardiovascular system diseases. Cancer mortality in the vanguard groups showed much less systematic progress, however, and even increased in Norway. This may become an important obstacle for future improvements in vanguard groups in the near future. The same inconsistencies can be observed for other groups of causes of death under study. Cardiovascular system diseases, which have dominated the modern structure of causes of death for several decades, are still the leading contributor to life expectancy improvements in vanguard groups. However, vanguard females in the three countries have already reached quite low levels of cardiovascular mortality and it is obvious that further progress in extending longevity limits will increasingly depend on advances in reducing cancer and other-cause mortality. There is still some room for further improvements at older ages, especially for age-related causes of death (such as Alzheimer's disease and other mental diseases).

The shift away from progress in cardiovascular diseases as the main driver of increased longevity towards a stage marked by the dominance of age-related diseases will represent a new phase in the health transition (Meslé and Vallin, 2006). The uneven success of vanguard groups in combating cancers and other causes of death may potentially signal a new divergence, reflecting the onset of the third age of the health transition in the three countries under study.

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Domantas JASILIONIS, Vladimir M. SHKOLNIKOV, Evgueni M. ANDREEV, Dmitri A. JDANOV, Denny VÅGERÖ, France MESLÉ, Jacques VALLIN • **DO VANGUARD POPULATIONS PAVE THE WAY TOWARDS HIGHER LIFE EXPECTANCY FOR OTHER POPULATION GROUPS?**

Do vanguard populations open new frontiers of survival and longevity that will eventually be reached by others? The main aim of this study is to identify the extent to which the non-vanguard populations in Finland, Norway, and Sweden might follow the mortality trajectories of the vanguard groups in these countries for different age ranges and for the major causes of death. The results show no systematic convergence between vanguard and non-vanguard sub-populations. On the contrary, they confirm the theory whereby each major epidemiological development initially gives rise to divergence in mortality trends. Our study found that at the sub-national level, rather than simply following (with a certain time lag) the same path as the vanguard groups, non-vanguard groups have their own pathways to low mortality which are related to specific determinants of mortality change. The study also found that a long time is needed for the non-vanguard group to attain the mortality levels already reached by the vanguard group at the start of the observation period. This is notably the case for the treatment and prevention of cardiovascular diseases.

Domantas JASILIONIS, Vladimir M. SHKOLNIKOV, Evgueni M. ANDREEV, Dmitri A. JDANOV, Denny VÅGERÖ, France MESLÉ, Jacques VALLIN • **L'AVANT-GARDE EN MATIÈRE D'ESPÉRANCE DE VIE MONTRE-T-ELLE LA VOIE AU RESTE DE LA POPULATION ?**

Les populations pionnières, bénéficiant les premières de l'augmentation de l'espérance de vie, ouvrent-elles pour les autres groupes la voie vers de meilleures chances de survie et de longévité ? Cette étude a pour but d'identifier dans quelle mesure, en Finlande, en Suède et en Norvège, la population qui n'appartient pas à cette avant-garde pourrait suivre les trajectoires de mortalité déjà tracées par les pionniers aux différents groupes d'âges et pour différentes causes de décès. Les résultats montrent qu'il n'y a pas eu de convergence systématique des trajectoires du reste de la population vers celles de l'avant-garde. Ils confirment an contraire la théorie selon laquelle chaque changement sanitaire majeur commence par induire une divergence dans les évolutions de mortalité. En effet, au niveau infranational, loin de connaître avec un certain délai les mêmes progrès que le groupe précurseur, le reste de la population suit son propre chemin de réduction de la mortalité, répondant à des déterminants différents. L'étude montre aussi qu'il faut un temps considérable pour que l'ensemble de la population atteigne les taux de survie dont l'avant-garde bénéficiait en début de période d'observation. C'est le cas notamment de la prévention et du traitement des maladies cardiovasculaires.

Domantas JASILIONIS, Vladimir M. SHKOLNIKOV, Evgueni M. ANDREEV, Dmitri A. JDANOV, Denny VÅGERÖ, France MESLÉ, Jacques VALLIN • **LA VANGUARDIA EN MATERIA DE ESPERANZA DE VIDA ¿MUESTRA LA VÍA AL RESTO DE LA POBLACIÓN?**

Las poblaciones pioneras, que benefician las primeras del aumento de la esperanza de vida, ¿abren a los otros grupos el camino hacia mayores posibilidades de supervivencia y de longevidad? Este estudio se propone identificar en qué medida, en Finlandia, en Suecia y en Noruega, la población que no pertenece a esa vanguardia podría seguir las trayectorias de mortalidad ya trazadas por los pioneros, en diferentes grupos de edad y por diferentes causas de muerte. Los resultados muestran que no ha habido una convergencia sistemática de las trayectorias del resto de la población con las de la vanguardia. Ellos confirman, al contrario, la teoría según la cual cada gran cambio sanitario comienza por provocar una divergencia en las evoluciones de mortalidad. En efecto, a nivel infra nacional, lejos de conocer con cierto retraso los mismos progresos que el grupo precursor, el resto de la población sigue su propio camino de reducción de la mortalidad, que responde a diferentes determinantes. El estudio muestra también que hace falta mucho tiempo para que el conjunto de la población alcance las tasas de supervivencia de las que beneficiaba la vanguardia al principio del periodo de observación. Es el caso, en particular, de la prevención y el tratamiento de las enfermedades cardio-vasculares.

Keywords: Finland, Sweden, Norway, life expectancy, mortality, causes of death, education, marital status.