Selection and mortality: a ten-year follow-up of income decile mortality in Norway

Dag Hofoss1, Espen Dahl2, Jon Ivar Elstad3, Milada Cvancarova2

1 Institute of Health and Society, University of Oslo, Oslo, Norway
2 Oslo University College, Oslo, Norway
3 NOVA—Norwegian Social Research, Oslo, Norway

Correspondence: Dag Hofoss, Institute of Health and Society, University of Oslo, PO Box 1130 Blindern, 0318 Oslo, Norway, tel: +47 22 85 05 65, e-mail: dag.hofoss@medisin.uio.no

Background: There is universal agreement that higher mortality goes with lower income. Opinions differ on causality: the association may reflect the damaging effect of poverty on health and survival chances. Conversely, it may reflect selection/reverse causation: low income indicates health problems, and from health problems follow a higher risk of dying. Methods: We studied all deaths in Norway (111 504) during the 10-year period 1994–2003 among persons aged 25–66 years in 1993 (2 261 076). For each year, age-standardized mortality rates were calculated for each 1993 income decile for men and women separately. Income was calculated as family size-adjusted income after taxes but including cash welfare transfers. If the selection theory was correct, one would expect to see the excess mortality in the poorer income deciles decline as the bad risks, over-represented in the lower income fractiles, die away. Results: Large income decile variations in mortality remained at the end of the 10-year period: after 10 years, the age-standardized mortality rate for men and women was still much higher in the lower income deciles. Conclusion: As the excess mortality in the poorer income deciles was not much reduced during the 10-year period, excess mortality among persons in bad health in the lower income deciles does not explain the income inequality in mortality in our data set.

Introduction

Health problems and increased mortality have consistently been shown to co-vary with income and socio-economic position: the more privileged have lower morbidity and mortality.1–4 The relationship has even been demonstrated in the relatively well-to-do and egalitarian societies with an advanced welfare state with universal health service coverage and high cash transfers, like the Nordic countries.5–8 Cash welfare benefits in Norway include—time-limited—sickness benefits and unemployment benefits, compensating for loss of income during sickness and absences from work and during periods of unemployment and disability benefits—permanent: once granted, they keep running until replaced by the general old-age pension when one reaches 67 years of age. Not part of the cash transfer system, but still relevant to the income gradient in mortality, is the fact that health care is not a big income gradient in mortality, is the fact that health care is not a big

The Nordic countries.5–8 Cash welfare benefits in Norway include—

time-limited—sickness benefits and unemployment benefits, compensating for loss of income during sickness and absences from work and during periods of unemployment and disability benefits—permanent: once granted, they keep running until replaced by the general old-age pension when one reaches 67 years of age. Not part of the cash transfer system, but still relevant to the income gradient in mortality, is the fact that health care is not a big
persons’ bank accounts or the value of their home or other assets. Still, the income inequality in mortality may even be increasing in western Europe,\textsuperscript{9} as well as in Norway.\textsuperscript{10}

On the question of the causal link between income and mortality, however, opinions differ strongly: do we see causation or selection? Unprivileged living may be bad for health. With fewer material resources at hand, one may end up with worse housing, in less healthy neighbourhoods, too little food or unhealthy food, etc., or, at least, in a position of relative deprivation and a stressing feeling of dissatisfaction with life.\textsuperscript{1,4}

A strong statement to the effect that inequalities in health follow from social inequalities was presented by the 2010 Marmot Review.\textsuperscript{11} However, the possible causal connection may also go the other way. The relationship of income to health may be produced by reverse causation. Among the materially underprivileged are many who have been sick for a while and who have had to change to part-time working or drop out of work completely. Excess mortality in lower income fractiles therefore is not necessarily caused by the socio-economic circumstances of lower-income earners. It may also reflect the sedimentation of unhealthier people, who run a higher risk of dying earlier, into the bottom layers of the income distribution, and, as shown by Fox, Goldblatt and Jones,\textsuperscript{12} the lower occupational classes contained disproportionate numbers of unemployed, sick or early retired persons. Additionally, as shown in the literature review by Palloni, Milesi, White and Turner,\textsuperscript{13} many\textsuperscript{14–24} have argued that at least partly the observed SES gradients are the outcome of selection mechanisms, whereby individuals in poor health early in life are more likely to experience downward mobility. In reaction to the Marmot Review, Chandra and Vogel\textsuperscript{25} pointed out that selection complicates the interpretation of the relationship of health to income, and Canning and Bowser\textsuperscript{26} argued in favour of viewing “the socio-economic gradient in health to be large part the result of differentials in health, reversing the direction of causality put forward in the Marmot reports”. Analyses of Norwegian data have concluded in the same direction. Rognerud and Zahl\textsuperscript{10} have argued that their results may indicate reverse causation: poor health caused low income, more strongly in 1997 than in 1970. Data from the Nord-Trøndelag health surveys\textsuperscript{28} have been interpreted along the same lines: the increased mortality of men of the lowest income quartile might be explained by life course development of health inequalities.

This article, limited to direct intragenerational selection, follows the income gradient in sex- and age-standardized mortality rates for the years 1994–2003, to see whether it flattened during the 10-year period, as would be expected from the selection hypothesis. We study all deaths in the entire Norwegian population aged 25–66 years in 1993 for the 10-year period 1994–2003. If the selection explanation holds, one would expect to see the excess mortality in the lower income fractiles petering out as the bad risks among the poorer die away, reducing their over-representation among the less well-to-do.

**Methods**

The data set was derived from official Norwegian administrative registers including the entire Norwegian population, and known for their completeness and data quality. Missing data are infrequent. In this study, the most common piece of missing information was vital status, which was unavailable for 1.4% of the men and women in the selected age span. The most common cause of missing data was emigration.

Data from the different registers were linked by means of the personal identification number and have been made available for the project by the Norwegian Social Science Data Service and Statistics Norway.\textsuperscript{29} To limit the study to that part of the population that had the chance of being occupationally active at the start of the period studied, we included in our analysis persons aged 25–66 years who were alive at the end of 1993 and whose vital status could be followed through 2003. The reason for excluding those under 25 was that many of them were students of low present income but on their way to well-paid jobs. The reason for excluding those over 66 was that Norwegians are entitled to old-age pension from the age of 67 years; among those over 66, the overwhelming majority are pensioners.

For each year during 1994–2003, the fraction who died during that year (of those who were alive at the beginning of the year) was calculated for each sex and each 6-year age group in each income decile (the age span of 25–66 years divides into seven 6-year intervals). The age-adjusted mortality rates of the highest income decile served as our point of reference. From these death rates was calculated, for each year and for each sex separately, the number of deaths to be expected in each age group in each of the lower income deciles if they had had the age group-specific death rate of the highest income decile. To show the excess mortality of each lower income decile, we then calculated for each year the standardized mortality ratio of each decile as the ratio of the observed number of deaths for that year in that income decile to the number of deaths to be expected from the age group-specific death rates of those in the highest income decile.

Changes in mortality trends were analysed using Cochran–Armitage test for time trends. It is similar to a crude chi-squared test, but it is more sensitive to the linearity between response variables and experimental variables and detects smaller changes that would not be noticeable using more crude methods. Mortality ratios were already adjusted for age groups and sex; therefore, there was no need to use a model-based method for assessing a trend.

To avoid misclassifying as poor married/cohabiting persons with no or low personal income—particularly married/cohabiting women, whose economic position is not well described by their own earnings—we calculated for each person not his/her personal income, but the income of the household to which they belonged. The same income will mean different levels of living for households of different sizes, and we adjusted post-tax household income for household size by the fairly common procedure\textsuperscript{30–32} of dividing the net amount calculated as described earlier by the square root of the number of family members.

Income was measured as family size-adjusted net 1993 income. As the Norwegian welfare system is fairly comprehensive, and the tax system is fairly progressive, income was measured after the inclusion of welfare cash transfers and after taxes. To calculate a family’s total taxable income, we summed all forms of income received in 1993 (wages, income from own business enterprise(s), bank account interests, profits from shares, etc., as well as all welfare cash payments received) by all members of the family (linked by the family’s unique number).

From the family’s total taxable income was deducted the sum of taxes paid by all members of the family, to produce an income figure reflecting the actual level of income at hand for the family, more closely related to the family’s standard of living than its gross sum of earnings.

The average family size-adjusted net 1993 income for 25–66-year-old men was 173 227 NOK (≈30 000 US$ or 22 000 €)—the range was 0–68 million (≈0–12 million US$ or 0–8.5 million €). Figures for women were about the same: average = 165 039 NOK (28 000 US$/20 000 €), range = 0–67 million (11 million US$/8 million €). The number of very rich was low; the highest family size-adjusted net income decile started at 249 419 NOK for men and 239 353 NOK for women—for both sexes 1–1.4 times the average family size-adjusted net 1993 income of Norwegian men and women aged 25–66 years.

The total number of persons aged 25–66 years alive at the start of 1994, of whom we had information on vital status through 2003 and on sex and net 1993 income (adjusted for family size), was 2 197 683—1 111 305 men and 1 086 378 women. The total number
of deaths during 1994–2003 among Norwegians born in 1927–68 (aged 25–66 years old in 1993) was 102 696 (47 per thousand of those alive at the start of 1994). The distribution of deaths by year for each sex and the number of persons alive at the start of each year are shown in table 1.

### Results

#### Men

As shown in figure 1, during the 10-year period, male excess mortality in the lower income deciles (relative to the richest decile, decile 10) was reduced (Cochran–Armitage test for trends, \( P < 0.001 \)). Still, large differences remained at the end of the period. The picture was practically the same for men aged 25–42 and 61–66 years as for all men in our data file (graphs not shown). Table 2 provides the same picture: the variation coefficient (VC) of decile SMRs for men was lower in 2003 than in 1994, but large differences remained at the end of the period.

#### Women

As shown in figure 1, during the 10-year period, female excess mortality (relative to the richest decile, decile 10) was not reduced (Cochran–Armitage test for trends, \( P = 0.15 \)): large differences remained at the end of the period. The picture was practically the same for women aged 25–42 and 61–66 years as for all women in our data file (graphs not shown). Table 2 provides the same picture: the VC of decile SMRs for women was practically the same in 2003 as in 1994.

### Discussion

The excess mortality of the lower income deciles did decrease somewhat, but not much, during the 10-year period 1994–2003. A possible interpretation is that individuals with bad health and higher risks of dying were over-represented in the lowest 1993 income deciles. As they die, the excess mortality should go down. The trend, however, was rather weak for men, and not significant for women. For both genders, large differences in mortality by income remained at the end of the period. The selection interpretation that the SMRs would tend to converge over time was hardly supported by our data, as SMR differences between the income deciles, for both genders, were only slightly reduced during the 10-year period and were substantial also in 2003. As shown in figure 1, the SMR for the lowest income decile in 2001 (men) and 2002 (women) deviated considerably from the overall trend. In an attempt to explain this, we have both checked the data for errors and examined whether special events occurred during those years, but we are not able to provide any plausible explanation for these fluctuations.

A strength of the analysis is the fact that it followed the mortality of the entire 1993 Norwegian population of persons born in 1927–1968, and that we controlled the income differences in mortality for sex and age. Sub-analyses for the younger (25–42 years) and the older (61–66 years) persons of the data set did not deviate from the results for the entire population. Also, we studied the effect of income after it has been adjusted for household size, not falling into the trap of considering as equal, a certain amount of earned money regardless of how many persons shall live off it. We also used net income, after taxes and welfare transfers, thus avoiding the risk of accepting at face value, high nominal incomes, which will be reduced by progressive taxation before the income earner and his/her dependants can start enjoying it.

A number of limitations must, however, be pointed out. First, we have only followed our subjects for 10 years, and the possibility that the mortality experiences of the income deciles will in the longer run conform to what is predicted by the selection hypothesis of reverse causation cannot be dismissed on the basis of our data: 10 years of follow-up may be too little.

Another important limitation is that we only have income data for 1 year (1993). We do not know whether that income year was typical or atypical for our individuals and households. Persons earning a lot in 1993 may have earned little in the years before or after (or vice versa), so that their true position in the national income hierarchy may not be well described by their 1993 income. Also, we lack data on material resources other than taxable income: having a social network and including a car mechanic, a dentist and a plumber may have considerable unregistered cash value. One may also worry that official income data may not accurately reflect true income—being taxation data, they may be coloured by an unknown degree of both fraudulent tax evasion and legal deductions. Such data inaccuracies will have the effect of narrowing the income distribution and attenuating the mortality differences between the income deciles. Norwegian tax authorities, however, are reputed to have a fairly accurate income registration system.

On the more technical side, it should be mentioned that the population data were only 98.6% complete. The most common cause of missing data was emigration. This may be a relevant source of error in this context: if old and sick immigrants go home to die, mortality in their income deciles is reduced. Immigrants are lower earners: in our data set, the average household income was 82% of the non-immigrant household income. This may mean that a selection bias has reduced income-related mortality differences. On the other hand,
Norway did not have a large immigrant population in 1993; in our data set, only 5.4% were first-generation immigrants; the immigrants were slightly younger than the native Norwegians (on average 40.4 years in 1993, native Norwegian average 1993 age was 43.1 years), and no one in our data set was older than 66 years in 1993.

Also, our data on household size are imperfect. The official data registers that produced our data did provide a unique family number for each individual. However, that number cannot be trusted to identify 100% correctly the actual household in which the person lived in 1993. The question of how to count grown-up children who—perhaps temporarily like students—do not live at home with their parents is unsolved. Additionally, as the cohabitation of couples not being formally married gets more common, the problem of identifying households correctly is growing. Grouping people into households by their official family numbers may include

---

**Figure 1** Decile 1 = poorest decile, Decile 10 = richest decile. Y-axis shows the ratio (multiplied by 100) of the expected to the observed number of deaths in each income decile; were the deciles to have the same mortality rates as the richest income decile in each (6-year) age group

**Table 2** Standard deviation (SD) and VC of decile SMRs, by gender and year

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men aged 25-66 years</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>71</td>
<td>69</td>
<td>60</td>
<td>63</td>
<td>66</td>
<td>63</td>
<td>58</td>
<td>50</td>
<td>60</td>
<td>54</td>
</tr>
<tr>
<td>VC</td>
<td>0.42</td>
<td>0.42</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.37</td>
<td>0.37</td>
<td>0.33</td>
<td>0.38</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>Women aged 25-66 years</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>43</td>
<td>39</td>
<td>42</td>
<td>44</td>
<td>43</td>
<td>46</td>
<td>38</td>
<td>56</td>
<td>38</td>
<td>42</td>
</tr>
<tr>
<td>VC</td>
<td>0.31</td>
<td>0.30</td>
<td>0.31</td>
<td>0.30</td>
<td>0.29</td>
<td>0.32</td>
<td>0.27</td>
<td>0.33</td>
<td>0.27</td>
<td>0.29</td>
</tr>
</tbody>
</table>
among the true low-decile earners, people who do not belong there. Mixing the real low earners with cohabiting couples whose incomes should have been pooled and whose living expenses are reduced by not having to maintain two separate households may have had the effect of underestimating the income decile mortality differences. The same can be said for parents of students who have left their childhood home but are still formally registered as living with their parents.

Much of the research into the socio-economic gradient in mortality—in particular English research—has studied health-based selection into occupational classes I–V, and not health-based selection into income groups. Our data only allowed us to look into the income gradient in mortality. The mechanism of health selection effect into income deciles may differ from the health-based selection into occupational classes.

It should also be borne in mind that our data set consisted of persons aged 25–66 years in 1993, i.e. born 1927–68, whom we followed for 10 years. We had no data on their position earlier in life. Our conclusions therefore refer only to the relationship of mortality to adult income, and can say nothing about the effects of life course selection on the basis of possible early formative experiences. Neither did we have data on intergenerational mobility, but we can only speak on intragenerational direct health selection.

The income effect of bad health may be smaller in Norway than in other countries. In the Norwegian welfare state, even a serious health problem does not ruin a person’s economy. Government-financed health care offers free hospital treatment, and the welfare system cash transfers ensures that disabled persons do not slide into poverty if they must give up their job. In an international perspective, the selection into lower income deciles of persons in bad health may therefore be less pronounced in the Nordic welfare states than in many other countries.

The most important caveat, however, is that finding that the excess mortality in the lower income fractiles did not decline much during the 10 years studied is not tantamount to proving the selection theory wrong. Early excess mortality among the poorer might be effects of long-term exposure to the disadvantages of low income and/or bad health followed by reductions in income. One might even argue that because of an income effect on health, people die; therefore, the effect of social causation wears off with time. As stated earlier, we only had income data for 1 year. Also, we had no baseline health data, and are therefore unable to entangle whether excessive deaths are due to selection or causation—most likely both processes are operative.

Acknowledgements

Anonymized data were provided by Statistics Norway and the Norwegian Social Science Data Services. Neither is responsible for the analysis of the data and the interpretations presented.

Preliminary results from these analyses were presented and discussed at the ISIG (International Study of Income Gradients in Health) research group meeting in San Francisco, 6–8 September 2010.

Before the anonymized data was sent to us for analysis, our research plan was approved by the relevant government institutions: the Norwegian Data Inspectorate (Datatilsynet) and the Governmental Board of Health (Helsetilsynet), which decided that the research plan did not impinge on patient and citizen rights to anonymity and privacy.

Funding

The project was supported by a grant from the Norwegian Research Council [Project number 163970/V50].

Conflicts of interest: None declared.

Key points

- The current article tests one of the implications of the selection/reverse causation explanations of the social gradient in health: if bad risks die earlier, the excess mortality of the poorer income deciles will wear off over the years.
- Selection was not a strong explanation of the higher death risk in the lower income deciles, at least not in the context of the affluent Norwegian welfare state. During the 10-year period studied, the age- and sex-adjusted mortality rates of the poorer income deciles did not sink much towards the mortality rate of the richest decile.
- Policies to reduce economic inequalities may be relevant to public health and should not be discarded on the basis of the idea that the income gradient in mortality merely reflects the selection of bad risks into the lower income deciles.

References

Introduction

Life expectancy (LE), the average number of years a person can expect to live given the current age-specific mortality rates, is a meaningful measure of population health. LE varies from country to country and by gender, with women tending to live longer than men. These patterns though are far from uniform.

As a reflection of the overall mortality level of a population, LE at birth increased dramatically in the 20th century generally owing to both improved public health conditions (e.g. hygiene, nutrition and medical practices) as well as social policies fostering greater educational attainment, and improved economic and relative incomes. In particular, Organization for Economic Co-operation and Development (OECD) countries have enjoyed a 10-year increase in LE within a single generation.

Gender gaps in life expectancy: generalized trends and negative associations with development indices in OECD countries

Yan Liu1, Asuna Arai1, Koji Kanda1, Romeo B. Lee2, Jay Glasser3, Hiko Tamashiro1

1 Department of Global Health and Epidemiology, Hokkaido University Graduate School of Medicine, Sapporo, Japan
2 Behavioral Sciences Department, De La Salle University, Manila, Philippines
3 School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas, USA

Correspondence: Hiko Tamashiro, Department of Global Health and Epidemiology, Hokkaido University Graduate School of Medicine, Kita 15 Jo Nishi 7 Chome, Kita-ku, Sapporo 060-8638, Japan. Tel: +81 11 706 5051, Fax: +81 11 706 7374, e-mail: tamashiro@med.hokudai.ac.jp

Background: Life expectancy (LE) is a major marker of individual survival. It also serves as a guide to highlight both the progress and the gaps in total social and societal health. Comparative LE in concert with measures of gender-specific experience, indices of empowerment and societal happiness and development offer a comparative tool to examine trends and similarities of societal progress as seen through the lens of cross-national experience.

Methods: To determine the gender gaps in LE (GGLE) trends, we performed a longitudinal analysis, covering a period of 49 years (1960–2008). To examine the association of GGLE with development indices, we used the 2007 GGLE data, the newest happiness data mostly drawn from 2006; the 2006 Human Development Index (HDI) data and the 2006 Gender Empowerment Measure (GEM) data. Results: It revealed that most of the Organization for Economic Co-operation and Development (OECD) countries had a GGLE trend that occurred in an inverted U-curve fashion. We divided them into three subgroups based on the peak years of respective GGLE. The earlier the peak year, the happier the countries, the higher the HDI and the smaller the current GGLE are. Association analysis indicates that Happiness, HDI and GEM are all negatively associated with GGLE. Conclusion: This pattern suggests that GGLE undergoes three phases of growth, peak and stability and decline. Japan will soon be seeing its GGLE gradually shrinking in the foreseeable future. The continuing increases in Happiness, HDI and GEM are associated with a decrease in GGLE, which should be carefully taken into consideration.