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Abstract

There is still much uncertainty about the impact of income inequality on health and mortality. Some studies have supported the original hypothesis about adverse effects, while others have shown no effects, and a few even indicated beneficial effects. In this investigation, register data covering the entire Norwegian population were used to estimate how income inequality in the municipality of residence, measured by the Gini coefficient, affected mortality in men and women aged 30-89 in the years 1980-2002, net of their individual incomes. The total exposure time was about 55 million person years, and there were about 850000 deaths. Adverse effects were estimated when individual and average income and some other commonly used control variables were included in the models. However, because there are annual measurements in each municipality, the data provide a rare opportunity to include also municipality fixed-effects, to pick up time-invariant unobserved factors at that level. When this was done, there was actually more evidence for beneficial than for adverse effects. In addition to illustrating the potential importance of the fixed-effects approach, these findings should add to the scepticism about the existence of harmful health effects of income inequality, and especially in a Nordic context.

Introduction

The idea that income inequality may weaken people's health and increase mortality has attracted much interest in recent years (see e.g. reviews by Kawachi, 2000; Wagstaff and van Doorslaer, 2000; Lynch, Davey Smith, Harper et al., 2004; Wilkinson & Pickett, 2006). Some investigators have used an ecological approach to check whether societies (e.g. countries, states, municipalities) with large variation in income fare worse than others in terms of health and mortality, and many of these studies, but far from all, have concluded that there indeed seems to be such a relationship. A particularly robust pattern has been seen within the United States. However, a positive relationship between income inequality and mortality in an ecological analysis may simply reflect diminishing individual health returns to increasing individual income. A more interesting question is whether individual health and mortality are adversely affected by the income inequality in the community, net of individual income. Two hypotheses suggested in the literature are that such effects might be due to a higher probability of psychosocial stress from relative deprivation among people in societies with large economic inequality, or to a generally lower level of mutual trust and social cohesion (see details below). Unfortunately, the empirical evidence from the multilevel research is highly mixed. Whereas some studies have supported the hypothesis about adverse effects of income inequality – and especially American ones where inequality has been measured at the state level – no effects, or in a few cases even beneficial effects, have shown up in other investigations.

When assessing the effect of income inequality, one must of course control for structural characteristics that are determinants of income inequality and also have an impact on health (but not necessarily for factors that income inequality is likely to operate *through*, though that distinction is often difficult to make in practice). One simple example of such a potential confounder is whether the place is urban or rural: urban societies typically offer a diversity of jobs, and may therefore also produce large income differences, in addition to showing high mortality for many other reasons, at least in rich countries. Another possibility is that unsocial policies may lead to both economic inequality and general under-investment in public health institutions. Obviously, there are many such socio-economic, environmental, political or other factors that are likely to affect people's health as well as the local labour markets and the productivity differentials, the importance of productivity for wages, and the consequences of wages for economic well-being.

Many of the potentially confounding characteristics are difficult to measure, or may not be included in the available data, but fortunately some of them are approximately time-invariant, for example because they are somehow linked to the physical characteristics of the communities. These can be captured by including fixed effects, i.e. a 0/1-dummy variable for each unit at a certain level of aggregation. The most promising approach would be to include such fixed effects at the same level of aggregation as the income inequality is measured (along with any relevant time-varying observed factors at that level). This is essentially a difference-in-difference technique: One checks whether the communities with a particularly sharp increase in income inequality also have had the poorest development in health or mortality, all else similar, in which case the evidence for adverse effects of income inequality is reckoned as particularly strong. Mellor & Milyo (2001) estimated difference-in-difference models with ecological data for American states, and for a selection of countries, and found in many cases that the inequality effect was markedly dampened in such models compared to those seen in the more commonly estimated models.

However, no one has estimated *multilevel fixed- effects* models to assess the importance of income-inequality for health and mortality.[1] This is probably largely due to practical limitations: The inclusion of such community fixed effects requires measurements at two or more different times for each community, and such data are scarce.[2]

The present study is based on register data that cover the entire Norwegian population, and that include individual migration histories, as well as biographies of, for example, individual education and income. The migration histories identify all municipalities in which a person has lived during the period under investigation. The municipality, of which there are currently 431 in Norway, is the lowest political-administrative unit in the country (see details below). By aggregating up from the individual data, one can easily establish measures of income inequality and various other socio-economic characteristics for each municipality for all relevant years. Thus, the data are, so to speak, longitudinal both at the individual and municipality level and have the structure needed for a fixed-effects analysis. The focus of the study has been in on all-cause mortality at age 30-89 in 1980-2002, and a Gini coefficient computed from individual gross incomes has been used as the inequality measure. The data set is huge by any standard: About 850000 deaths are included in the analysis.

The municipality is responsible for much of the public health care, though under strong national directions, so it should be a theoretically meaningful level of analysis. Little is known about the social and geographical extent of people’s comparisons with others. Given modern communication systems, it may often stretch beyond the municipality, but it could also in many cases be restricted primarily to smaller neighbourhoods (or even socially defined subgroups of these neighbourhoods).

Nordic countries have smaller differentials in earnings and, even more markedly, in disposable incomes than most other rich countries (e.g. United Nations, 2006). However, differences do exist, and there is also a certain *variation* in inequality between municipalities, and even variation in the *trends* in inequality, which is required for the fixed-effects estimation (see details below). It is hard to believe that people in Nordic countries do not react much like any other population to whatever inequality there is. The social and psychological mechanisms thought to be relevant for other rich countries are probably not completely irrelevant in the Nordic setting, although they may not necessarily produce a response of exactly the same strength. The empirical evidence, which is modest, does not suggest any Nordic uniqueness either: Results from earlier investigations (none of which have employed the fixed-effects approach) have been just as mixed as those from other European countries. For example, no effect of inequality was found in a very thorough Swedish analysis based on about 40000 individuals living in 284 municipalities (Gerdtham & Johannesson, 2004). In Denmark, Osler and her colleagues (2002, 2003) saw considerable variation in effects, for example across sexes and by level of aggregation (parish vs municipality), and even estimated some beneficial effects. From Norway, Elstad, Dahl & Hofoss (2005) reported a clear mortality-enhancing impact of income inequality when 23 larger regions were considered. To conclude, an analysis based on the rich Norwegian register data and relatively advanced techniques should be a potentially important contribution to our knowledge about the impact of income inequality, though perhaps not shedding so much light on the importance of very *large* income inequality.

The setting

The physical environment in Norway is very diverse. There are, for example, densely populated urban areas as well as small coastal communities and a great variety of inland rural settlements. The travelling time to a large city is long for many people, partly because of deep fjords or high mountains. This variety creates differences in economic activity and lifestyles, and even with a political ideology that puts emphasis on equality of opportunities (e.g. Kautto, Heikkilä, Hvinden & Marklund,1999), it is hard to avoid a certain variation in incomes and in the access to health and other services. For example, the income per person is twice as high in the richest municipalities as in the poorest (calculated from data used in this study). As further described below, there is also substantial variation in income inequality.

Regional differences in mortality do appear, for example at the level of counties, of which there are 19 in Norway: Men's life expectancy at birth currently ranges from more than 78 years in some counties in Western Norway to less than 75 years in the northern county of Finnmark (Statistics Norway, 2006), with the corresponding figures for women being 83 and 81 years. The country also has substantial socio-economic differentials in mortality (e.g. Kunst, Bos, Andersen et al., 2004). Some authors have actually claimed that they are sharper than in many other European countries (Mackenbach, Kunst, Cavelaars, Groenhof & Geurts, 1997).

The size of the municipalities differs greatly. Oslo, the capital, has about half a million inhabitants, and there are 4 other large urban municipalities with a population of 100000 - 250000. Among the other municipalities, the average population size is about 7000, with a variation from 200 to 75000.

Theoretical considerations

It is trivial that, all else equal, a person selected randomly from a municipality with large income inequality is more likely to have low or high income than a person selected randomly from a municipality with less inequality. Assuming that the positive health effect of high income is less pronounced than the corresponding negative health effect of low income, the person from the municipality with large income inequality will tend to have the highest mortality. In other words, if individual income is not included in the model, a mortality-enhancing effect of income inequality may be explained by diminishing health returns to individual income. However, is there also likely to be an effect of income inequality on a person's mortality *net of individual income* (and net of average income, which may be linked with income inequality)? Two possible reasons were mentioned very briefly above, and a more thorough and critical review will now be provided.

One idea that has been advanced is that income inequality operates by producing feelings of relative deprivation (e.g Kawachi 2000, Wagstaff & van Doorslaer 2000; Lynch et al. 2004). Apparently, the underlying assumption has been that a person who is surrounded by others who are much richer may be subject to a psychosocial stress that may affect health partly through psychoneuro-endocrine mechanisms and partly through health behaviour. However, while that may well be true, one would need more detailed knowledge about the source of the stress before an impact of income inequality can be predicted. This seems not to have been sufficiently recognized in the literature. The problem can be explained through some simple examples: Assume first that there are only three possible levels of income: I1, I2 and I3. Assume further that there is a society A with little income inequality, where most people have income I2 and rather few have income I1 or I3, another society B with more income inequality, where a larger proportion earn I1 or I3, and yet another society C, having the largest income inequality, where there is a uniform distribution over the three income levels (i.e. 1/3 at each income level). If stress for a person who earns I1 is primarily caused by a *high proportion of people having higher incomes* (meaning that there are also few at the same low level to share the burden with), the *least* unequal society A will be the worst to live in. If, on the other hand, it is a *high income average among those who earn more* that is problematic, the *most* unequal society C would be the worst. Or perhaps those who are in a *very* different situation economically are simply ignored in everyday comparisons, in which case A, B and C would be equally bad (the average among those who earn more, disregarding those earning I3, is I2 in all three societies)? Or perhaps the most intense feeling of deprivation is produced if a person sees *many with **much** higher income*, and perhaps this feeling is also strengthened (rather than buffered) if there are many in the same situation who can sensitize each other to the problem? If so, the stress for a person with income I1 would increase both with the proportion earning I1 and the proportion earning I3, i.e. society C would once again be worst. Should a lower income I0 also be possible, one might raise the question whether a large proportion at that level would mitigate, and perhaps even more than outweigh, any stress felt by a person with income I1 as a result of the richer people (i.e. those with income I2 or I3). These examples show that it is far from obvious how income inequality affects the health of a person with relatively low income, even if one accepts the general idea the existence of richer people in the community may somehow produce a harmful stress reaction. Besides, there is another side of the coin, which suggests an interaction between income inequality and individual income: Just as a high income inequality, under certain assumptions, *may* be harmful to one with relatively low income, it *may* be *beneficial* for one with relatively *high* income, depending on whether there is a similar type of *pleasure* to be derived from having an income *advantage*.

A second main argument for an effect of income inequality (launched for example by the authors referred to above) is that large differences between people with respect to incomes, and therefore also in general opportunities and perhaps life styles, contribute to undermine “social cohesion”, i.e. weaken people’s trust in each other and lower the chance that one may get assistance from others in case of health problems or more generally (the latter having possibly a preventive effect). While this may sound plausible, there has actually not been overwhelming support for such an inverse relationship between income inequality and social cohesion, and it has not been consistently shown that social cohesion is important for health. Some researchers have argued that a high level of social cohesion improves the health, while others have seen no such effects (see e.g. Kawachi & Berkman 2000; Mohan, Twigg, Barnard & Jones, 2005; Veenstra, 2005) In fact, it has even been suggested, although without empirical backing, that a cohesive community may contribute to overburden people with obligations (Martikainen, Kauppinen & Valkonen, 2003).

Anyway, one may speculate whether there is a positive counterpart of this type of argument: If there are large differences in lifestyles, partly because of a substantial income inequality, a great diversity of leisure activities and civic associations may result. There will be fine restaurants and inexpensive cafes side by side, and tennis courts and golf clubs as well as football grounds. This diversity might perhaps benefit everyone, and especially those with a preference for activities more widespread outside their own social class.

A third suggested reason for effects of income inequality is that, although the relatively poor may want stronger public investments in health and social services, the rich will favour a lower tax level and have a dominant voice (see once again the same references). This argument may have limited relevance for Norway. To the extent that local decisions are important (given national regulations and national and local resources), they would be based on elections. The size of health investments is among the politically least controversial issues, and it has not been documented that the election results are linked to income inequality.

A fourth reason, which is rarely mentioned in the literature, is an extension of the diminishing-returns argument referred to in the beginning: In a society with much inequality, there will be more people with poor health or unfavourable health behaviour than in a society with the same overall income level but more equity. Perhaps this poor health behaviour among some people is transmitted to others through social learning or influence (e.g. Montgomery & Casterline 1996), or that a high prevalence of health problems might reduce the access to health services for other people (i.e. a "crowding out" argument)?

To summarize, there are some arguments for adverse effects of income inequality, most of them apparently quite widely accepted. However, they are not impressively strong, and it is, in fact, possible to argue for the opposite as well, i.e. that large inequality may promote *better* health. There is even some empirical support for the latter: Beneficial effects have shown up in a few multilevel studies, at least for certain sub-populations and without control for some variables that have a particularly ambiguous causal position (Mellor & Milyo 2003; Osler, Christensen, Due et al., 2003; Wen, Browning & Cagney, 2003). The authors have not given these negative findings much attention, though, and have not felt tempted to provide any causal interpretations.

Adding to the complexity, it is indeed plausible that the effect of income inequality depends on the person's own individual socio-economic resources (e.g. Mellor & Milyo 2002; Kahn, Wise, Kennedy & Kawachi, 2000). One reason, among several, was mentioned above. In this study, only a very simple check of such cross-level interactions is made, leaving more detailed explorations to future analyses. It is also possible that sex and age may be modifiers, just as seen for other community socio-economic variables in mortality analyses (e.g. Robert, 1999; Kravdal, 2006). For example, one may speculate whether economic deprivation is felt more intensely at some ages than others, or for one sex more than the other, or whether the general importance of health institutions and other societal factors (as opposed to individual resources and attitudes) differs across age and sex. Sex and age variations have only attracted some attention in a few earlier studies of income inequality and health, and no clear picture has emerged from this research (e.g. Lynch et al., 2004).[3] In the present analysis, sex and age variations were consider by estimating models separately for men and women and for six different age groups.

Besides, it was experimented with lags, because most of the mechanisms suggested above may need time to be forceful (see, for example, Blakely, Kennedy, Glass & Kawachi (2000) and Mellor & Milyo (2003), who found sharper effects of income inequality lagged a few years than when current income inequality was considered). Finally, it is possible that some mechanisms are more relevant for some causes of death than for others. For example, there seems to particular support for an adverse effect of income inequality in studies focusing on homicide or other violent deaths (e.g. Lynch et al., 2004). In the present analysis, a side-view has been taken to a few potentially interesting causes.

Data and methods

Data

The data were taken from population censuses and various national population registers, and included all men and women who lived in Norway and were of age 30-89 some time during 1980-2002. Similar data have been used in several previous studies (e.g. Kravdal, 1995, 2000, 2006). For each person, there is information about date of death, cause of death, annual incomes, and the highest educational level attained as of 1 October each year. In the version of the data available for this analysis, all migration between municipalities was recorded with dates and a consistent set of codes for the municipalities that people have moved to and from. These codes were not equal to the real municipality numbers, so municipalities could not be identified by the researchers. However, municipality variables could be constructed by aggregating over the individual data. (There were 433 municipalities in these data, but because of a few very recent border changes, there are now 431 municipalities in Norway.) In one set of models, counties were used similarly as the level of aggregation instead of municipalities.

In the study population, the total exposure time was about 55 million person-years, and there were about 850000 deaths.

Statistical approach

Discrete-time hazard regression models were estimated, using Proc Logistic in SAS. The follow-up was from January the year the person turned 30 or, for those born before 1950, January 1980. Each person contributed a series of 12-month observations. (These intervals were sufficiently short, because a length of 6 months gave the same results.) All individual variables were time-varying and referred to the situation at the start of the 12-month observation interval or earlier. The municipality variables referred to the situation in the observation interval in the municipality in which the person lived at the beginning of that interval. The variables are described in detail below.

The models were estimated separately for men and women and for six 10-year age groups. This was primarily because of the size of the material (e.g. about 7.5 million one-year observations and 10000 deaths among men aged 30-39, 1.3 million observations and 150000 deaths among men aged 80-89, and more than 460 variables in the most complex models). In addition, such stratified modelling easily reveals whether the effects vary across sex and age.

Details about income variables

The only income information available in these data was the annual gross labour earnings reported to the tax authorities. This is not necessarily a good measure of the person’s purchasing power, which also depends on the income of the partner (if any), the number of persons in the household, accumulated wealth, special tax benefits or disadvantages, public transfers, and (especially for the elderly) pensions.

All incomes were converted to 1000 NOK (Norwegian “kroner”) in 1998 prices, by means of the consumer price index.

One obviously cannot include in the model the annual income for the one-year observation interval, because those who died that year did not have the opportunity to work a full year. However, it is also problematic to include the income in the previous year, which may be low because of the health problems (for reasons completely unrelated to the economic situation) that are also the reason for the death. While not a perfect solution, it would at least help to lag the income variable more years, and that also seems a good strategy because any causal effect of income may need some time to be felt. Given also the substantial *variations* in income over time for some persons, the individual average income over the years 6-10 before the observation interval was used as the individual income variable. Years with missing income (because the person did not live in the country) were ignored when calculating this average. If there was no income information for any of the 5 years, the income variable was set to 0 (any number would do) and a missing-income variable was set to 1 (otherwise 0). There were about 1% such missing-income observations.

Because there is no similar endogeneity problem at the aggregate level, income inequality, measured by the Gini coefficient, and average income can be based on income data for the observation interval (excluding the missing values, of course). When constructing these variables, it was summed over the ages 30-69, when at least most of the men work full time. It is not obvious whether women should be included. If they are, one captures (trends in) regional differentials in women’s labour participation, which in turn reflect a variety of socio-economic and ideational factors. Unless otherwise stated, both sexes were included when average income was computed (mean over the 22 years under study was 126000 NOK and standard deviation was 27000), while they were excluded in the computation of the Gini coefficient.[4] However, alternatives were tried (see elaboration below).

There was indeed regional variation in the Gini coefficient and in its trends. Its average value was 0.37, the standard deviation was 0.05, the minimum level was 0.23 and the maximum level was 0.51.[5] Relatively high levels were seen especially in Oslo and Northern Norway. The Gini coefficient increased over the 22 years under study, although not monotonously. If a linear trend was assumed, the overall increase was 0.0014 per year. This trend varied across municipalities, from 0 to 0.0028 (standard deviation 0.0004).

Other individual and municipality variables

In addition to individual income, also age (within the 10-year age interval; defined as a continuous variable) and period (in one-year categories) were included in the models, for obvious reasons. There has been a discussion in the literature about the inclusion of education in models used to assess effects of income inequality (e.g. Lynch et al., 2004). On the one hand, a person's current educational level is a very important determinant of that person's income, and, similarly, community education has a bearing on the general level and distribution of income. On the other hand, current education may also be a *result* of the community's investments in education some years back, which in turn is linked with the degree of income inequality at that time.

In the models presented in the tables, individual education was included. It was defined as the highest level achieved as of 1 October the year before (grouped into 4 levels, plus a special indicator for the 2% with missing education). Average education (mean =11.4 years, standard deviation=0.59) was also included in some models. It was calculated by aggregating over individual education for the age group 30-69 years, because this age group was used in the construction of the average income and the Gini coefficient. In addition, it was experimented with the inclusion of average education in age group 30-89.

Municipality fixed effects

Although estimates from simpler models are shown for comparison, the main results are from models that included municipality fixed effects (0/1 dummies for each of the 433 municipalities, except one reference municipality). As explained above, these fixed effects capture time-invariant unobserved municipality characteristics that may influence both income inequality and health.

Some of the municipalities are very small, which produces large standard errors of the corresponding fixed effects.[6] Because the municipalities cannot be identified either, the fixed effects are not shown. In some models, the 100 smallest municipalities were left out. This gave the same patterns in the estimates (not shown).

In the models without municipality fixed-effects, a municipality-level random term might have been added to the intercept, to take into account that those who live in a municipality have something in common that is not captured by the available variables. This is standard procedure in multilevel modelling (e.g. Goldstein, 1995). However, it would be difficult with such a large number of observations, and in this investigation it would not be worth the effort anyway, given the modest attention paid to these models. One should merely keep in mind that the community effects estimated from those models are actually somewhat less significant than indicated in the tables.

Results

The adverse effects of income inequalities that have been reported in several other studies (including that from Norway by Elstad et al. (2005)) appeared for both sexes and for all age groups in the simplest ("standard") models that only included age, period, individual education and income, average income, and the Gini coefficient. This is seen in Table 1, where all effect estimates for women at age 70-79 are shown, as an example, and in Table 2, where only the effects of the Gini coefficients are shown. The age pattern was nice: The higher the age, the weaker the inequality effect.

However, when the municipality fixed effects were added, a very different pattern appeared. In these models, a significant adverse effect was only seen at age 30-39, and there were indication also at ages 40-49, while the effects at higher ages were beneficial, or (for age 50-59) there was at least an indication in that direction. Among women, there were no significant effects at any age.

It might also be noted from Table 1 that the mortality-*enhancing* effect of high average income seen in the simplest model disappeared in the fixed-effects model. This was found also for some other age groups, for both sexes, but significant mortality-*reducing* effects, which are more in line with common expectations, were estimated for men aged 60-79 in the fixed-effects models (not shown).

(Tables 1 and 2 about here)

As a robustness check, a series of alternative models were estimated, though only for men and women aged 30-39, 50-59 and 70-79 (for purely practical reasons; even with these age restrictions, the estimation took 22 hours for each alternative). More precisely, the following was done (only estimated from the fixed-effects models are referred here; estimates from "standard" models can be seen in the tables):

1. Some other age restrictions (30-59, 30-64) were chosen when calculating the Gini coefficient. This gave the same pattern in the estimates (not shown).
2. Age standardization was tried, because the Gini coefficient may pick up the age structure (e.g. large inequality may be a result of a large proportion relatively old or young), which in turn may be linked to mortality in a complex manner.[7] Fortunately, this also gave the same results, except that the effect for women of age 70-79 attained significance at the 10% level (Model 2, Table 3).
3. It was experimented with 5- and 10-year lags, by including in the models the level of income and income inequality 5 or 10 years earlier in the municipality where the person lived at that time. The municipality fixed effects also referred to this municipality. With a 5-year lag, the results were very similar, but the point estimate for women aged 30-39 was more positive, and a more clearly significant beneficial effect appeared for men aged 50-59 (Model 3, Table 3). With a 10-year lag, this adverse effect for the youngest women turned significant, while the adverse effect for the youngest men was now only significant at the 10% level (Model 4, Table 3). Also inclusion of average income and income inequality 5 or 10 years earlier in the municipality where

the person lived at the start of the observation interval (rather than 5 or 10 years earlier), gave very similar results (not shown).

4. Women were included when calculating the Gini coefficient. Once again, the same pattern showed up in the mortality effect estimates, though there was a clearer indication of an adverse effect among women aged 70-79 and the effect for men aged 50-59 was more strongly significant (Model 5, Table 3).
5. Average education at age 30-69 was added to the model, which had no impact on the estimated effects of the Gini coefficient (Model 6, Table 3). This was true also when average education at age 30-89 was included (not shown). (According to the fixed-effects models, a high average education at age 30-69 reduced mortality significantly among women at age 50-59. A high average education at age 30-89 reduced mortality significantly also among men at ages 50-59 and 70-79. Otherwise, this variable had no effect.)
6. The average income among men was included, rather than that for both sexes pooled. This gave the same pattern in the estimates (not shown).[8]
7. Generally, inclusion of individual income makes the effects of inequality less positive or more negative, but the differences are rather small (not shown). To see whether a better control for individual income would be important, a grouped variable with 13 categories, including one for 0 income (which was a large groups among the oldest, many of whom had already retired 6-10 years earlier), was tried as an alternative. This gave very similar results, however (not shown). Shorter lags were also tried. For example, the inclusion of income 1-5 years before, rather than 6-10 years before, led to nearly the same estimates (not shown). For men and women at age 70-79, it was also experimented with the inclusion of average annual income during an earlier

period, age 50-59, when at least the men were very likely to have worked (excluding years before 1968, for which the income is not known, or any year abroad). Earlier labour incomes may themselves be important, in addition to determining the level of the retirement pensions. A strongly significant beneficial effect of high income inequality was still seen among men, while a harmful effect showed up for women, now significant at the 5% level (not shown).[9]

(Table 3 about here)

To see whether effects of income inequality perhaps were more adverse among the socio-economically least advantaged, models were estimated separately for i) those with only compulsory education (about half in the oldest age groups and 20% in the youngest) and ii) for men aged 50-59 or 60-69 with an income below the average for men aged 30-69 in the municipality that year (since individual income refers to the situation 6-10 years earlier, and the general annual growth in incomes is only a few percent, the current average for the 30-69 age group would be a reasonable reference). It turned out that the inequality effects were not particularly adverse for any of these groups. In fact, the estimates were very similar to those for all persons in the respective age groups (not shown).

Because it has been suggested that effects may be sharper with a higher level of aggregation, additional models were estimated for all age groups and both sexes with county rather than municipality as the basic regional unit. The results were remarkably similar (not shown). The only difference worth mentioning is that the effect among women at age 70-79 was more markedly adverse (point estimate 0.77, significance level <0.01).

Finally, it was focused on a few specific causes of death for which earlier studies have suggested particularly adverse effects of income inequality, or of low social cohesion (see also Martikainen et al., 2003): Alcohol related deaths, suicide, and all violent deaths pooled. There were no harmful effects in any of these fixed-effects models (not shown). Homicide was not considered separately, since there are only about 50 such deaths in the country each year.

Summary and conclusion

This investigation based on Norwegian data provides some support for the idea that large income inequality has a harmful effect on health. Such effects were seen most clearly among men in their 30s, and there were also indications for men in their 40s. In addition, adverse effects appeared for some groups of women with certain model specifications. Among older men, there seemed to be *beneficial* rather than adverse effects.

There is no obvious reason why effects should be particularly harmful among the youngest men. One might speculate whether, for example, inferiority is more intensely felt at the lower ages and particularly hard to accept for men. It is also possible that psychosocial and other factors potentially influenced by income inequality have more effect on the causes of death occurring relatively frequently at low ages, such as violent deaths. In that case, however, one would expect to see adverse effects for these causes of death in the models estimated for the older men and women, which did not show up.

Admittedly, there are some potential weaknesses in the present study. In particular, it is the individual gross labour income that is used rather than household disposable income. Control for individual income actually appeared not to be very important, so the key issue is probably whether a Gini coefficient computed from individual incomes is a sufficiently relevant indicator of inequality, or rather whether the geographic differentials in the trends in inequality are adequately reflected. The fact that it did not matter whether women's incomes were included when computing the Gini coefficient suggests a certain robustness. Besides, it may be argued that the municipality is a too low level of aggregation for some of the suggested mechanisms to be played out in full. However, the results were very similar when counties were used as the level of aggregation, and the harmful inequality effects that have been proposed by many researchers *did* show up in the more traditional models similar to those usually estimated by other researchers.

The income inequality is generally modest in Nordic countries. It is not impossible that the larger inequalities in, for example, the United States have fundamentally different effects, or that also inequalities of about the same size in some other European countries may have another impact, because of somewhat different political systems and ideological traditions. However, there are many studies from non-Nordic countries also that do not support the original inequality hypothesis, and in those that apparently do, other conclusions might have been reached with better controls for confounding factors – for example by including fixed effects, which has been shown here to be a powerful tool.

Some scepticism about the existence of adverse inequality effects seems indeed warranted, and it may be time for scholars in this research area to revisit the theoretical argumentation. As discussed above, some of the common arguments are perhaps not very strong after all: Can we be so sure that income inequality really undermines social cohesion substantially, or that it is responsible for generally stressful feelings of relative deprivation? Does weakened social cohesion really exert the allegedly harmful health effect? Is it actually the case that rich people can block poorer people's interest in improving social services? Besides, ideas about possible beneficial effects – whether related to diversity of lifestyle opportunities, which was suggested above, or something else - deserve to be further developed. Another implication of the results from the present investigation is that we should be more conscious in the future about the possibility that any effect of income inequality may differ markedly across age groups and between sexes.

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Table 1. Effects (with standard errors) on the log-odds of all-cause mortality among women aged 70-79, 1980-2002, according to discrete-time hazard models estimated from register data for the entire Norwegian population. [a]

	Standard model		Fixed-effects model	
Gini coefficient in the municipality	1.223****	(0.079)	0.271	(0.178)
Average income in the municipality (in 1000 NOK)	0.0015****	(0.0001)	0.0007	(0.0006)
Individual income (in 1000 NOK)	-0.0038****	(0.0001)	-0.0038****	(0.0001)
Missing individual income				
No[a]	0		0	
Yes	0.256****	(0.073)	0.259**	(0.073)
Education				
9 years[a]	0		0	
10-12 years	-0.184****	(0.007)	-0.179****	(0.007)
13-16 years	-0.313****	(0.016)	-0.308****	(0.016)
17- years	-0.182***	(0.056)	-0.178***	(0.006)
missing	0.075***	(0.028)	0.075***	(0.028)
Period				
1980[a]	0		0	
1981	-0.044**	(0.020)	-0.040**	(0.020)
1982	-0.081****	(0.020)	-0.069****	(0.020)
1983	-0.090****	(0.020)	-0.071****	(0.020)
1984	-0.130****	(0.020)	-0.105****	(0.020)
1985	-0.080****	(0.020)	-0.051**	(0.020)
1986	-0.154****	(0.020)	-0.118****	(0.022)
1987	-0.119****	(0.020)	-0.080****	(0.022)
1988	-0.136****	(0.020)	-0.089****	(0.023)
1989	-0.165****	(0.020)	-0.114****	(0.023)
1990	-0.135****	(0.020)	-0.075***	(0.024)
1991	-0.208****	(0.020)	-0.140****	(0.025)
1992	-0.232****	(0.020)	-0.158****	(0.026)
1993	-0.245****	(0.020)	-0.152****	(0.029)
1994	-0.292****	(0.021)	-0.204****	(0.029)
1995	-0.271****	(0.021)	-0.185****	(0.030)
1996	-0.327****	(0.021)	-0.241****	(0.032)
1997	-0.326****	(0.021)	-0.236****	(0.035)
1998	-0.353****	(0.022)	-0.261****	(0.039)
1999	-0.380****	(0.022)	-0.281****	(0.042)
2000	-0.408****	(0.022)	-0.304****	(0.044)
2001	-0.432****	(0.023)	-0.320****	(0.046)
2002	-0.410****	(0.023)	-0.301****	(0.051)
Age (years)	0.105****	(0.001)	0.105****	(0.001)
Municipality fixed effects			Yes	

[a] Reference category

* p<0.10; ** p<0.05; *** p<0.01; **** p<0.001

Table 2. Effects (with standard errors) of the Gini coefficient on the log-odds of all-cause mortality among men and women aged 30-89 in 1980-2002, according to discrete-time hazard models estimated from register data for the entire Norwegian population. [a]

	Standard model	Fixed-effects model
MEN		
30-39	3.109**** (0.260)	2.562**** (0.636)
40-49	2.356**** (0.198)	0.938* (0.479)
50-59	1.852**** (0.137)	-0.558* (0.315)
60-69	1.445**** (0.091)	-0.581*** (0.208)
70-79	1.126**** (0.068)	-1.605**** (0.152)
80-89	0.683**** (0.073)	-0.524*** (0.163)
WOMEN		
30-39	3.648**** (0.399)	0.205 (0.968)
40-49	3.041**** (0.275)	0.152 (0.682)
50-59	2.218**** (0.191)	0.046 (0.443)
60-69	2.071**** (0.126)	-0.089 (0.288)
70-79	1.223**** (0.079)	0.271 (0.178)
80-89	0.530**** (0.063)	-0.041 (0.144)

[a] Age, calendar year , individual income, individual education, and average income were also included.
* p<0.10; ** p<0.05; *** p<0.01; **** p<0.001

Table 3. Effects of the Gini coefficient on the log-odds of all-cause mortality among men and women aged 30-39, 50-59 or 70-79 in 1980-2002, according to discrete-time hazard models estimated from register data for the entire Norwegian population. [a]

Standard model

	Model 1: As in Table 2	Model 2: Age standardized Gini coefficient	Model 3: 5-year lag in municipality variables	Model 4: 10-year lag in municipality variables	Model 5: Women included when computing Gini coefficient	Model 6: Average education 30-69 also included
MEN						
30-39	3.11****	3.06****	2.51****	1.98****	3.75****	3.01****
50-59	1.82****	1.87****	1.45****	1.12****	1.84****	1.79****
70-79	1.13****	1.19****	0.85****	0.68****	0.71****	1.06****
WOMEN						
30-39	3.65****	3.60****	2.91****	2.19****	2.33****	3.43****
50-59	2.22****	2.24****	1.95****	1.69****	1.36****	2.17****
70-79	1.22****	1.22****	1.00****	0.91****	0.80****	1.24****

Fixed-effects model

	Model 1: As in Table 2	Model 2: Age standardized Gini coefficient	Model 3: 5-year lag in municipality variables	Model 4: 10-year lag in municipality variables	Model 5: Women included when computing Gini coefficient	Model 6: Average education 30-69 also included
MEN						
30-39	2.56****	2.67****	2.27****	0.90*	3.07****	2.65****
50-59	-0.56*	-0.52*	-1.10****	-1.07****	-1.02***	-0.60*
70-79	-1.61****	-1.54****	-1.52****	-1.50****	-1.85****	-1.60****
WOMEN						
30-39	0.21	0.27	1.21	1.62****	0.19	0.08
50-59	0.05	-0.04	0.01	-0.12	0.05	-0.11
70-79	0.27	0.33*	-0.01	0.09	0.35*	0.28

[a] Age, calendar year, individual income, individual education, and average income were also included.
* p<0.10; ** p<0.05; *** p<0.01; **** p<0.001

Notes

[1] Mellor & Milyo (2002, 2003) estimated a multilevel model with fixed effects, but those fixed effects were at a level above states, while inequality was measured at the state level or below. (Anyway, inclusion of the fixed effects had a sharp impact on the estimate of the inequality effect.)

[2] The choice of methods may also be influenced by field-specific traditions. It seems that fixed-effects modelling, for some reason, is less common in social epidemiology than in the neighbouring field of demography and, even more so, economics.

[3] For example, Lobmayer & Wilkinson (2002) found (in an ecological analysis) that the effects of income inequality were restricted to people younger than 65, while Blakely et al. (2002) saw indications that effects were sharper above age 45 than below. Differences between sexes have received some more attention, and a few authors have reported marked sex variations (e.g. Osler et al. 2003), but there is no consistent pattern in these findings.

[4] To motivate that decision, let us assume the existence of two equally large populations A and B consisting only of couples. In population A, all men earn I + R and all women I - R (with R<I of course). In population B, all men and women earn I. The sum of men's and women's incomes, which is the same in A and B, seems to be a good measure of the level of affluence in society and, for example, the economic opportunity to establish health care facilities (while, if only men's incomes were considered, A would appear to be the richest population.) However, if both sexes are included in the calculation of an individual-based Gini coefficient, A would appear to have more inequality than B. To the extent that *household* economic resources are the key factor in the mechanisms relevant for health (reviewed above), that might seem unreasonable. If we instead leave out the women, A and B would appear as having the same degree of inequality (though women have a relatively poorer position in A, which is surely an important difference from other perspectives).

[5] A continuous version of the Gini coefficient was used, rather than grouping first the persons into, for example, the 10% earning most, the 10% earning second most etc.

[6] All the municipality fixed effects were between -0.7 and 0.4 for women aged 70-79, and about 1/4 of them were significantly different from 0 at the 0.05 level, but the fixed effects were more volatile at higher or lower ages, of course.

[7] There may be causal effects. Besides, an old age structure may be partly a result of low mortality in the past

[8] Average income was positively linked to mortality in the standard models, but according to the fixed-effects models, a high income – whether measured at age 30-69 or 30-89 - *reduced* mortality significantly among men older than 70, while there were no effects in the younger age groups and for women (not shown). Average education is closely correlated with average income, but leaving one of these two variables out had little impact on the estimated effect of the other (not shown).

[9] A few other sensitivity tests were also made: Exclusion of individual education had an impact on the effect of individual income, of course, but left otherwise little

imprint on the estimates. Nor did inclusion of individual marital status, which was available in the data and known to be a key determinant of mortality, affect the inequality effect estimates.