Income Inequality and Health: The Story So Far

and

Its Implications for Understanding Regional Mortality Trends within the US

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Over the last 10 years, there are few issues that have captured the imagination of public health researchers and advocates, as has the question, whether the extent of income inequality drives levels of population health – both within and between countries. This theme in social epidemiologic research has coincided with a heightened awareness and concern over the extent of income inequality between the rich and poor within countries, and the gaping chasm of inequality between rich and poor nations. In addition, there has been an increased interest in understanding the capacity of environmental characteristics, not conceptualized or measurable as characteristics of individuals - but rather as characteristics of places or aggregates of people - to affect the health of individuals[1]. Many so-called "contextual" health effects have been proposed[2], including social capital and the extent of income inequality.

The basic proposition behind questions over income inequality and health is rather simple. If we consider all the individuals who live within a defined geographic area such as a country or a region within a country, one could sum the total incomes of those individuals and calculate the mean. As any introductory statistics course would explain, a distribution - in this case of individual or household incomes - can be described in terms of its central tendency and some measure of the variation around that central tendency. Thus, the basic question for income inequality research has been whether the extent of variation in the distribution of income affects health, net of absolute income. Or, in other words, after control for absolute income differences, does relative position in the income hierarchy (i.e., variation) affect health.

This was indeed a "big idea"[3] that attracted contributions from scholars motivated by the humanitarian potential of showing how health could be improved through greater equity and social justice. It was also an important idea because of its obvious relevance for redistributive fiscal and tax policies. Just days after we published our analysis of income inequality and

mortality among US states in the *BMJ* in 1996[4], the then Labor Secretary in the Clinton administration – Robert Reich, a long-time advocate for policies that would decrease inequality – contacted us to get a copy of the paper. If one accepts the notion that income inequality, or what it stands for, is a determinant of population health, then places that deliberately even out the life chances of individuals by having more egalitarian income distribution and social policies, will produce better overall health for their inhabitants. This is an appealing, intuitive and policy relevant idea.

One of the questions facing us now is whether this idea has had its fifteen minutes of academic fame? Our most recent work[5] and several papers recently published in the *BMJ* prompted an editorial comment by Johan Mackenbach that explained "… evidence for a correlation between income inequality and the health of the population is slowly dissipating."[6] Thus, it seems this research theme is at something of a crossroads. However, we are now in a better position to address some of the questions concerning the relevance of income inequality for population health.

- Does it help explain average differences in population health between countries?

  The best evidence we have says probably not, except perhaps for some health outcomes such as infant and child mortality.

- Does it explain regional differences within countries?

  In US studies, the extent of income inequality across states and metropolitan areas has been consistently and robustly associated with a variety of health outcomes. There are however, on-going debates about such issues as what constitutes proper control for

confounding and which group(s) are appropriate for comparisons of "relative disadvantage."[7]

- Does it operate similarly within all countries?

  The sum of the evidence suggests that the effects of income inequality on health differs across countries. There are strong effects on health in the US, some rather weak and inconsistent effects in the UK[8], but no effects have so far been seen within Canada, Australia, Denmark, Sweden, Japan or New Zealand.

- If the effects are not universal, then under what conditions does the extent of income inequality affect different aspects of individual and population health?

  Gaining answers to this question is the next phase of income inequality research. It is perhaps premature to completely dismiss the work on income inequality and health. It remains relevant, especially for less developed countries and countries in transition, to consider if there are ways to buffer the health effects of income inequality, which historically has risen with economic development[9]. It appears that when the extent of income inequality is strongly linked to many forms of other social investments in health, and with racial/ethnic diversity[10] that income inequality - or as we believe, the health enhancing infrastructure for which it is a convenient marker - is likely to be linked with health.

- How should the association between income inequality and health in the US be understood?

  While the aggregate cross-sectional association seems solid, questions remain about both aggregate and cross-level confounding. These issues center around whether income

inequality is a marker for other contextual characteristics of regions, states or cities in the US, or whether it is confounded by compositional characteristics of these areas such as race/ethnicity and individual income.

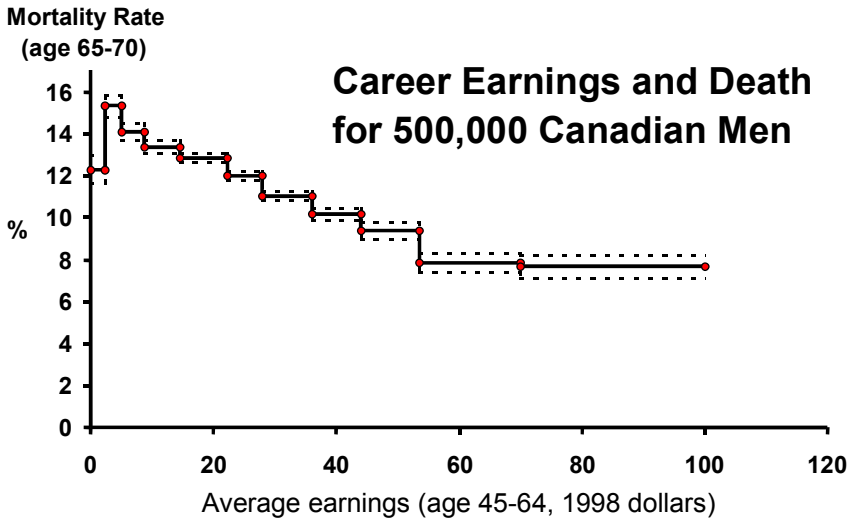
The first part of this paper will review "the income inequality story" with each short chapter trying to briefly capture the essence of the main issues as they emerged over time. The second part of the paper will begin to examine whether income inequality affects regional differences and trends in mortality in the US.

Chapter 1. The Puzzle

It is widely accepted that at the individual level, higher incomes - and other markers of socioeconomic position (SEP) - are associated with better health[11]. This relationship is found for many but not all disease outcomes, and across many but not all places and over many but not all time periods. While the consistency of this association is emphasized by most authors[12], we often overlook the heterogeneity of its strength and direction. These are under-investigated aspects of the link between socioeconomic factors and health that should be pursued in future research[13-15]. The relationship between income and health at the individual level involves more than poverty. Every step up the income ladder is generally associated with an increment - albeit a diminishing increment - in health, and a reduction in mortality. In other words, there is an individual-level gradient. Furthermore, with the analysis of powerful datasets that follow individuals in general populations over time, evidence has converged around the general conclusion that SEP precedes poor health[16]. The most persuasive studies have involved prospective analyses of large, representative cohorts[17-19]. Wolfson and colleagues[20] looked at the relationship between past

earnings and mortality for over half a million male Canada Pension Plan contributors and retirees. Figure 1 shows the relationship between mortality in the 65 to 70 age range and each individual's average level of earned income between ages 45 and 65. The graph shows a clear gradient. It must be emphasized that this is not just at a point in time; these are longitudinal data, so they show the connection between income at as early as age 45 and mortality experienced decades later, after age 65. The causality, for the majority of cases, must run from income to mortality, and not the other way around. Moreover, the magnitude of this gradient in terms of the public health impact is substantial. If the 80% of men with the lowest earnings were somehow able to achieve survival rates of the top fifth, the increase in life expectancy would be roughly the same as if cancer as a cause of death were completely eliminated for this cohort of men.

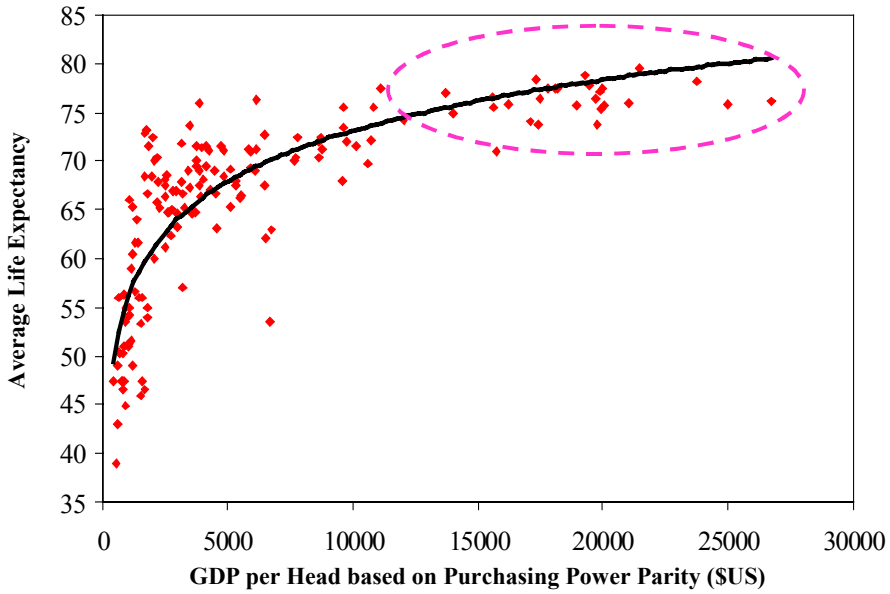
Figure 1: Career Earnings and Death for 500,000 Canadian Men



Thus it seems clear that there is an unambiguous causal association between individual level income and individual health. This relationship is not just about the difference in health states between the poor and the rich: being middle class is better than being poor, and being rich is better still in terms of health outcomes.

Similar patterns can be observed if countries are the units of analysis. The well-known association between GDP per head and life expectancy is seen in Figure 2.

Figure 2. GDP per head and Life Expectancy for 155 Countries.



The curvilinear shape implies that above a certain income threshold the link between absolute income and health loosens, so that the variation in population health (illustrated in the circle) is not tied as tightly to average income. Among these richer countries, the strength of the association depends crucially on which countries are included[5,21,22]. Nevertheless, it is precisely

this unexplained variation in average levels of health between countries that in part inspired the notion that if it was not average income, then perhaps it was the distribution of income within these countries that helped explain why some rich countries had better levels of health than other rich countries. Of course the puzzle here is that we know that within each and every one of these countries, levels of income are strongly related to health among individuals.

Chapter 2. The Big Idea

"The big idea is that what matters in determining mortality and health in a society is less the overall wealth of that society and more how evenly wealth is distributed. The more equally wealth is distributed the better the health of that society. One political implication, appealing to those on the left, is that the best way to improve health in a society might be to take measures to distribute wealth as equally as possible."[3]

Concerns about social inequality are not new. They have been voiced throughout human history, and are germane to ideas of democracy and justice. For a variety of reasons inequality has often been seen as an undesirable characteristic of a society, because of its potentially disruptive effects on civic functioning, or its implications for the rise of reactionary political movements, or because of its offense to moral sensibilities. Indeed over the last 15 years, there has been an enormous amount of discussion in both academic and popular circles about the growth and extent of income inequality within and between countries[23,24].

In a seminal 1975 paper[25], Preston examined the association between per capita national income and life expectancy at birth, for three different decades of the 20th century. He demonstrated that life expectancy in the 1900s, 1930s and 1960s exhibited a non-linear relationship with per capita national income. Above a certain threshold, gains in life expectancy

were not related to higher levels of average income. In addition, the relationship between income and life expectancy had shifted upwards during the 20th century. Preston made several points in discussing these findings that are pertinent to the topic of this paper. First, he proposed that upward shifts in the life expectancy/income association were mainly due to "exogenous" factors that strengthened the public health infrastructure (immunization, technological advances, and specific disease control campaigns) rather than income growth *per se*. In other words, social investments in health-enhancing resources "ramped up" the link between income and health without changing the basic nature of the association between the two. Second, he suggested that over time, life expectancy had become progressively more dissociated from absolute income level, and that at least some of the variation in life expectancy at the upper income levels may be due to variations in income distribution between countries.

While Preston could not examine this issue directly because the available data were inadequate, he did show mathematically how income distribution could affect the total mortality burden of a population. He explained that because the association between income and life expectancy was asymptotic (increases in income produced diminishing returns on increased life expectancy), those with incomes below the average lost more years of life, than were gained by those with higher than average incomes. Preston concluded that, "The distribution of income is clearly a likely source of variance in the basic relation between national life expectancy and average national income…"[25, p.242]

In 1979, Rodgers was the first to elaborate empirically and mathematically how income distribution was associated with population health[26]. In a sample of about 50 countries, he empirically tested a model that predicted life expectancy at birth, at age 5, and infant mortality as a function of mean income level, and income distribution. Rodgers' overall concern was to try to

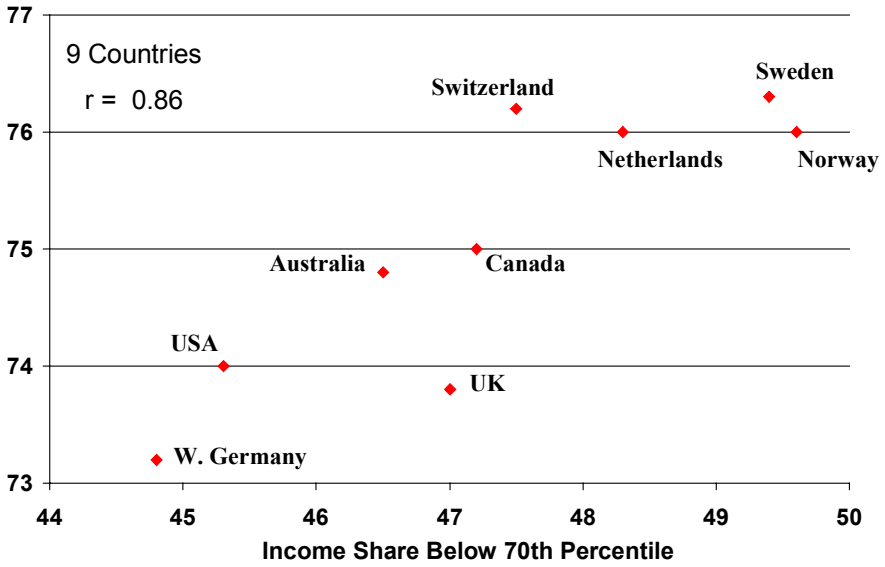
understand the determinants of mortality change, especially in regard to developing countries, and he presaged many of the issues that have since occupied researchers in this field. He recognized that specific factors like clean water, sanitation, food supply and health care - aspects of health-enhancing infrastructure investment - were important but empirically difficult to disentangle because they tend to be highly collinear with each other and with income. That realization certainly remains salient today. He noted that disentangling their specific contributions was important for policy formulation, but not " … critical for a description of mortality changes in the process of development (p. 343)." He thus set aside the messy issues of figuring out appropriate confounders and specifying causal pathways that might link aspects of development, income, inequality and population health. Rodgers also explicated what Gravelle later called the "artefact"[27] issue and showed how the curvilinear individual association between income and health will produce an apparent effect of income inequality on health at the population level. However, he was unable to directly examine this because he only used aggregate data.

Rodgers examined different characterizations of the income and inequality variables in regard to life expectancy and infant mortality. Throughout the paper, Rodgers presented the most robust formulations of his statistical models, as judged by P-values for coefficients and the amount of variance explained (R^2 value). He was thus primarily concerned with the efficient predictive statistical functioning of the models, not whether they were causal representations. Indeed, he offered no substantive interpretation of his findings and clearly left open the possibility that associations between income inequality and health could be due to confounding by health and social services, including education. Nevertheless, he argued that there was 5-10

years difference in life expectancy between relatively egalitarian and inegalitarian countries. And thus, the first empirical plank in the income inequality and health story was in place.

In a series of papers produced since the mid 1980's Richard Wilkinson demonstrated important associations between income inequality and differences in mortality between

Life Expectancy and Income Inequality (Late 1970s - Early 1980s)



Wilkinson. *Unhealthy Societies* (1996, p.76) - from an LIS Working Paper

industrialized countries. His most widely cited study, published in 1992, used income data from the Luxembourg Income Study and showed that the percentage share of total post-tax and benefit income held by the least well-off 70% of the population was strongly related to life expectancy at birth[28]. This association was unaffected by adjustment for average absolute income level and was evident across a range of decile shares of the income distribution (Figure 3).

Figure 3. Wilkinson's results on income inequality and life expectancy

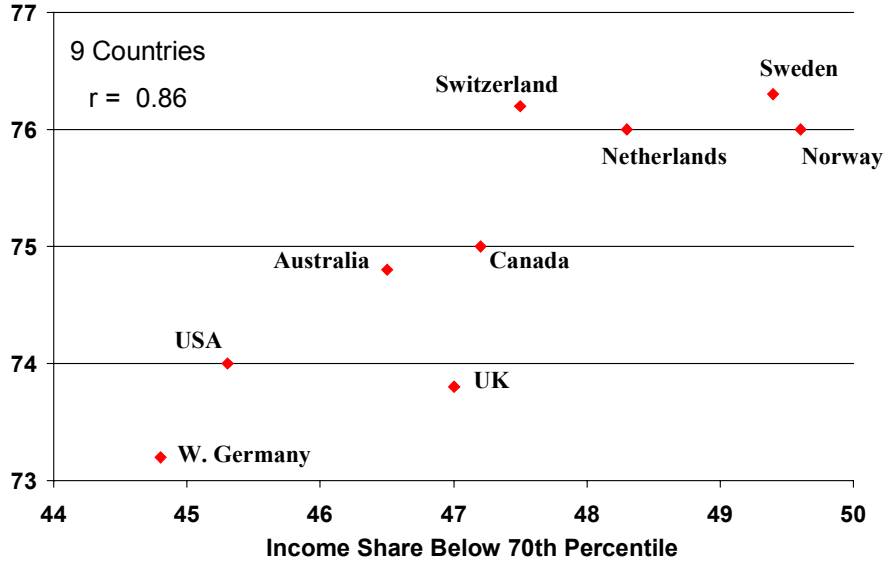
Furthermore, using two other data sources, he showed how changes in income share were associated with changes in life expectancy. Wilkinson's observations were extremely important

and controversial, not just because they could shed light on why income and health were related within, but not between countries, but also because they had direct relevance to economic policies that might affect public health.

Chapter 3. Data, Measurement and Interpretive Controversies

In 1995, Ken Judge authored a critique of the work linking income inequality with mortality[29]. In his critique, Judge focused almost exclusively on the work of Wilkinson (1992), and claimed that re-analysis of new data that had been added to the Luxembourg Income Study data base (LIS) " . . . casts doubt on the hypothesis that inequalities in the distribution of income are closely associated with variations in average life expectancy at birth among the richest nations of the world." (p.1282). These same criticisms were repeated by others who also showed that re-analysis of the updated LIS information failed to support a statistically significant association between income distribution and life expectancy or changes in life expectancy. At least part of the problem was that Wilkinson had used an early release of the first wave of LIS data and there had apparently been an updated version of the income data for some countries - in

Life Expectancy and Income Inequality (Late 1970s - Early 1980s)



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particular Germany. These corrected data markedly changed Germany's income inequality rank (Tim Smeeding, LIS Director, personal communication).

These criticisms of Wilkinson's research argued that there were problems with the validity of some of the data that Wilkinson had used, i.e., they were differentially unreliable, covered different years, and were not gathered for the purpose of examining income inequality and health. Second, the basic income data that were used to generate distributional measures of inequality were not adjusted for taxes, benefits and household size. The idea here was that use of "raw" household income distributions would overstate the extent of inequality because they did not reflect the number of people who were supported by the income in each household, nor did they account for governmental policies that tax, and transfer money and benefits from the rich to the poor. Third, there was no rationale for the selection of the income inequality measure, and the association between income inequality and mortality differed according to which measure was used. Finally, Judge argued that any examination of the income inequality, life expectancy association must use multivariate techniques that can adequately control for other confounders.

Some of these early criticisms were answered by later within-country studies but two of them remain important to keep in mind for understanding the direction, findings and interpretation of later research. They are 1) Wilkinson's use of the uncorrected data on levels of income inequality in Germany, and 2) appropriate conceptualization and control for confounding at the aggregate and individual level.

Chapter 4. Replications Within the United States

There were 2 papers published in 1996 on the association between income inequality and age-adjusted mortality that corroborated Wilkinson's international findings[4,30]. First, in our paper, we used 1980 and 1990 US Census data that was based on pre-tax income from all sources, including governmental benefits, and examined mortality data from 1979-1981, and 1989-1991 provided by the National Center for Health Statistics in Washington, DC. We showed that the association between income inequality and mortality was not highly sensitive to the measure employed. In fact, including information from the companion paper by Kennedy and colleagues, the same substantive conclusions about the aggregate-level association between income inequality and health would be reached, based on use of the Gini coefficient, Robin Hood Index, or any percentile share of total income between the 10th and the 80th. Furthermore, subsequent analyses showed that these associations were also robust to some different definitions of income that accounted for taxes, benefits, and household size[4,31].

Kaplan et al.[4], showed that the income share held by the least well-off 50% of the population in each state, was strongly cross-sectionally associated with overall mortality in 1990 ($r=-0.62$, $p<0.0001$). This association was not affected by adjustment for median state income or poverty levels, was observed for almost all percentile shares of the income distribution, was consistent across age groups, and in both sexes. Furthermore, the share of total state income held by the least well-off 50% of the population was strongly associated with a number of other health outcomes, social and educational indicators – what we postulated as potential pathways between income distribution *per se* and health. It is also important to note that we already understood the importance of race and ethnicity to these findings. While we showed that income inequality affected mortality within race/ethnic groups, i.e., affected both black and white mortality,

adjustment for the racial/ethnic composition of states essentially eliminated the overall observed effect of income inequality on mortality. However, unlike subsequent researchers like Mellor and Milyo[32], and Deaton and his colleagues[33], we were less ready to attribute rather simplified racial composition explanations to observed links between income inequality and mortality. Indeed, we had many discussions about the "correct" way to handle differences in the race/ethnic composition of states – something that is obviously and fundamentally deeply rooted in the historical context of different US states. Thus, we were less willing to simply enter variables like "% of the state's population that was black" (or for that matter, dummy variables for state) into our statistical models and claim that we had 'put the gini back in the bottle'. We decided that such approaches to this analysis would leave us with as many questions as answers. We would merely ber substituting the question - why do states with higher income inequality have higher mortality? - for the question, why do states with higher proportion of blacks have higher mortality? If the percent of blacks in the state has a lot to do historically with the extent of income inequality – which it obviously does, then substitution of one question for another is perhaps unlikely to move knowledge very far forward.

The association between the share of the total income received by the least well-off 50% of the state population was consistently more strongly associated with mortality, other health outcomes, social and educational indicators than was the median absolute income in each state. In prospective analyses, income inequality levels in 1980 predicted changes in mortality between 1980 and 1990 ($r=-0.45$, $p<0.001$). The higher the level of income inequality in 1980, the slower the decline in mortality between 1980 and 1990. In similar analyses, Kennedy and colleagues[34], used the Gini coefficient, and the "Robin Hood Index". Their findings were entirely consistent with ours, and showed how the Robin Hood Index was strongly related to infant mortality,

coronary heart disease, malignant neoplasms, and homicide. Taken together, these two studies provided the first important corroborative evidence of the strong links between income inequality and population health. These observations were also later confirmed in US metro areas and counties[35,36].

Chapter 5. Its Just a Mathematical Artefact – The Need for Aggregate and Individual Data

By 1998 it seemed that the evidence for a link between the extent of income inequality and health was fairly solid – at least at the aggregate level. In fact, Richard Wilkinson had written in his book that "… there are a number of powerful reasons for thinking that relative income is more important than absolute income in the rich developed countries … This has now been demonstrated cross-sectionally and on data dealing with changes over time, and the relationship cannot be plausibly attributed to some intervening variables … This appears to be true in cross-country comparisons as well as within countries over time."[37,p.109] This was clearly an overstatement of the real evidence but it serves to illustrate the status and some of the enthusiasm for the hypothesis that income inequality drove levels of population health.

In spite of this enthusiasm, or perhaps because of it, criticisms of the work on income inequality and health were beginning to emerge.

The critiques of the US studies - instead of questioning data comparability and choice of jurisdictions as Judge had done in the international data - focused on two main lines of argument. The first was that any finding from an aggregate-level study design (i.e., one where places and not individuals are the unit of analysis) leaves open the possibility that the individual level relationship between income and mortality - explicated by Rodgers in 1979 - is sufficient to

produce a place-level correlation with income inequality and mortality, if there are a disproportionate amount of poor people living in high inequality places. In other words, the observed place-level relationship is a "statistical artefact"[27,29] generated by cross-level confounding of individual compositional characteristics. As a general principle, this concern is legitimate. Indeed, earlier authors[38,39] used exactly the same argument as Gravelle to theorize why we should expect population group level associations between income inequality and mortality. Nevertheless, the re-surfacing of this point served to call into question the basic validity of the observed aggregate-level associations.

The essence of Gravelle's argument is that we already have convincing evidence at the individual level for an income gradient in health. Statistically speaking then, all that is needed to generate a population-level relationship between income inequality and mortality (by aggregating individuals into areas) is a concentration of poor households in unequal areas. Would it not be possible, therefore, that the population-level results are some sort of statistical artefact, wherein the population-level relationship between inequality and mortality is nothing more than an aggregate-level reflection of the already well-established individual-level relationship? As pointed out before, this was nothing new to anyone working on income inequality and health, and had been pointed out by Preston and Rodgers more than 20 years before. It nevertheless, helped focus a more critical stance toward the evidence on income inequality and health, especially in regard to thinking more clearly about cross-level confounding.

Wolfson and colleagues employed an ingenious use of data simulation to show that Gravelle's argument was weak[40]. Gravelle's critique is in fact logically correct, but empirically appears only marginally significant – at least under the assumptions of the data simulations

employed. The essence of Gravelle's critique is based on the fact that the individual-level relationship between income and mortality is non-linear. For example, Figure 4, shows a clear, statistically very significant, and non-linear relationship between the risk of dying and household income. This relationship was estimated from data on household income and other demographic characteristics from the U.S. Census Bureau's Current Population Survey matched to the National Death Index, providing about 7.6 *million* person-years of mortality exposure from 10 years of follow-up. The other "population density" curve on the same graph shows how many individuals there were at each income level. It shows the characteristic shape where more than half the population have incomes below the mean, because of the long upper tail of the distribution.

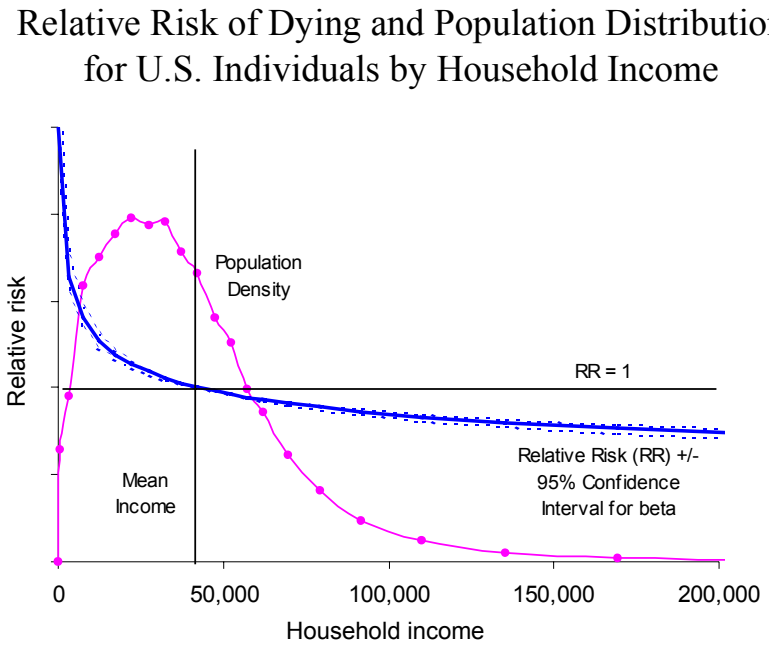


Figure 4. Relative Risk of Dying and Population Distribution for U.S. Individuals by Household Income

Figure 5 illustrates Gravelle's critique in a very simple case where we have two societies, A and B, each with two members. Society A is highly unequal, with member a1 having very low income, while the other member a2 has very high income. In contrast, incomes of b1 and b2 in society [illegible] societies have t[illegible]) We assum[illegible]ividual level, [illegible]by the downv[illegible]gure 4. Furthe[illegible]erlying the cu[illegible]etween incom[illegible]causal, but ce[illegible] of the data leads both to lower incomes and higher risks of dying; i.e. there are some selection effects, but these are not the major part of the explanation.

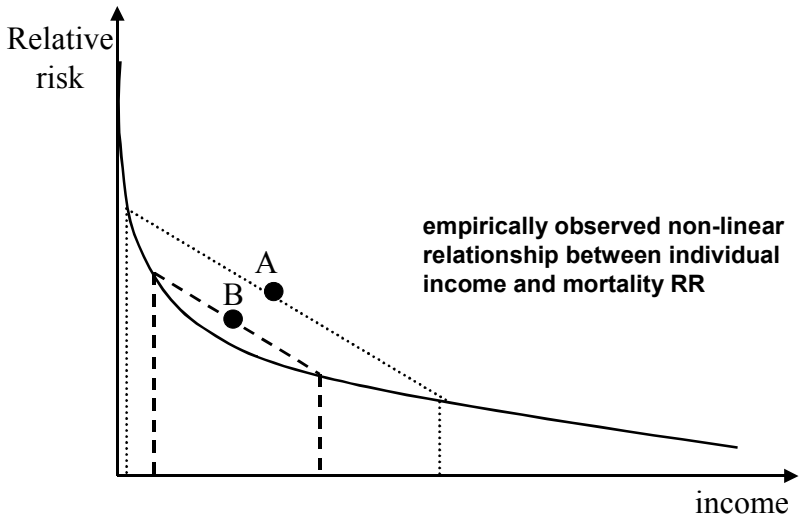
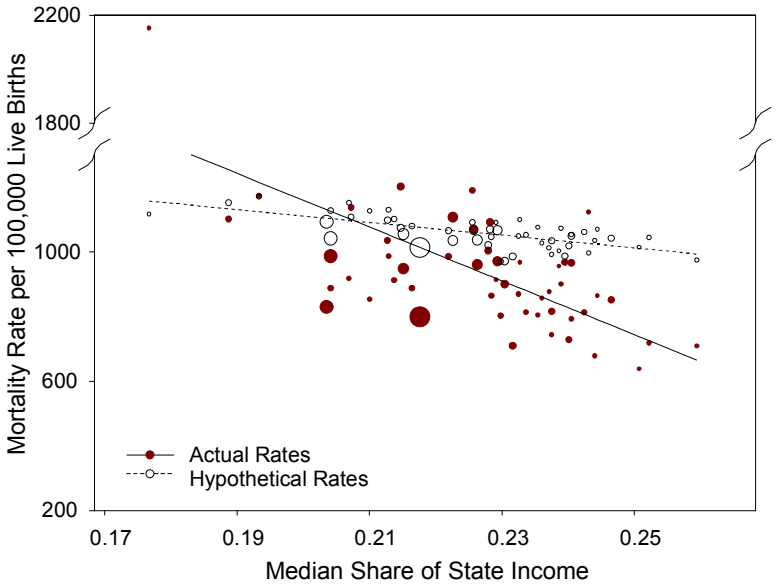


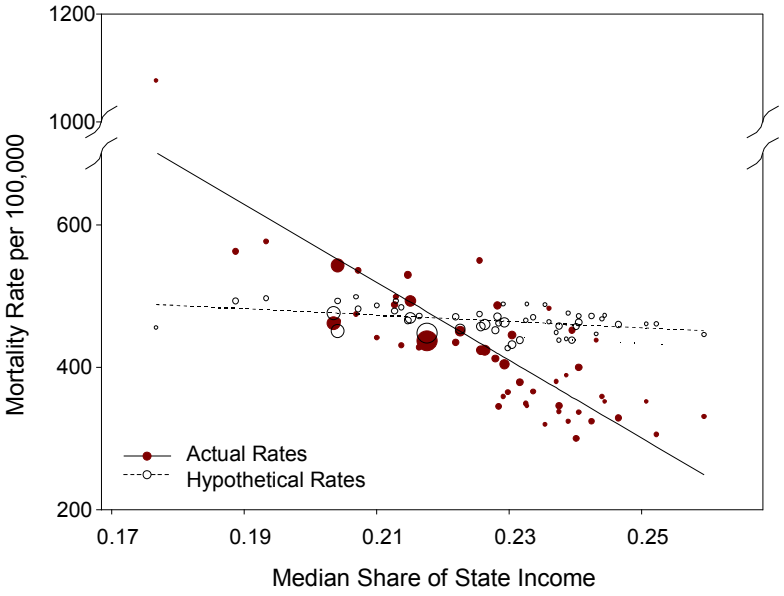
Figure 5. Hypothetical Pair of Societies

The larger dots at A and B along this relative risk curve are simply the average mortality risks of the two societies. Clearly, the dot for A is above that for B, so that the more unequal society B would be observed to have the higher mortality rate. The important point is that this aggregate observation would have nothing at all to do with the health effects of income inequality *per se*. Rather, it is simply the result of the curvilinear relationship between income and mortality operating at the individual level. This is the essence of the critique that the Wilkinson results internationally, or the Kaplan-Lynch results among states or cities in the US, in fact says nothing about the health effects of income inequality. It is merely a reflection of the underlying individual-level relationship.

Wolfson et. al.[40] provided an empirical assessment of this claim by working through the implications of Gravelle's critique *as if* it were 100% true. They calculated for each state what its mortality rate would be if the relative risk curve for the US were the sole source of mortality differences between states. To do this, data from the US census bureau were used on the numbers of individuals by state, age group, sex, and detailed income group. Analogous to Figure 5, for each state/age/sex/income group, their relative risk was determined using the curve in Figure 4, and the weighted average was computed for each state based on that state's income distribution. The results of these hypothetical calculations for two demographic sub-groups are shown in Figures 6a and 6b (unfilled circles), and compared to the actual mortality rates (filled circles).

Figure 6 (a,b). Scatter Plots of Hypothetical and Actual Mortality Rates for Infants and Working Age Males by Income Inequality, US States, 1990





The dashed lines show a simple linear regression for the hypothetical mortality rates, while the solid line is a fit to the actual data. There is a clear slope to the dashed line, so that Gravelle is certainly correct – income inequality combined with a curvilinear relationship at the individual level between income and mortality risk can indeed account for an observed relationship at the aggregate level between inequality and mortality. However, it is very clear from these graphs that the slope of the dashed line is nowhere near as steep as the slope of the observed relationship. Therefore, it seems that something must be going on over and above the "statistical artefact" in this relationship among U.S. states.

It is important to emphasize that this finding is more than a response to Gravelle's concerns. It also raises questions about earlier interpretations of the inequality-mortality

association by Duleep[38]. In these cases, the same argument as Gravelle's was used to explain why we should not be surprised to find, as they did, an association between income inequality and mortality at the level of population groups. These results for US states suggest that something more is involved - there is something about the broadly defined social context of economically unequal places - at least within the US - over and above individual characteristics that influences individuals' health.

Multilevel Studies

If we could design the perfect study to detect an effect of income inequality on population health what would we do? Clearly it would be imperative to design a study that would make explicit the notion that health is a function of both individual characteristics and features of the environment – both physical and social. Recent advances in the application of multilevel statistical techniques that allow for the simultaneous modeling of effects at both the individual level and at the population level[41-48] help tease out the net effects on health of societal level inequality, while controlling for individual characteristics, especially income. However, like any statistical model, these are not without their interpretive problems related to the proper control for confounding – something that is a conceptual as well as an empirical issue.

The results of these studies are mixed (for an excellent review see Wagstaff and van Doorslaer 2000[49]), perhaps due to variations in sample sizes of the studies, different outcomes employed, and the variety of geographic scales at which income inequality was measured. One concern with studies that find no effects (e.g. Mellor and Milyo, 1999[32]) is that based on their non-findings, they draw negative conclusions when all that is warranted is an agnostic one. Because of the data demands of these multilevel analyses, rather large sample sizes are required,

so the absence of a statistically significant result may be the result of insufficient statistical power rather than the absence of a hypothesized relationship. In fact, in our latest, but as yet unpublished analyses from the National Longitudinal Mortality Study, where we employ more sophisticated and powerful modeling techniques, shows that indeed there is an independent effect of income inequality on mortality among 25-64 year olds, over and above control for individual characteristics like income, education and race. We were even able to show an effect of income inequality after further control for the racial composition of the state, so that while income inequality and race are highly correlated across US states, there does appear to be some residual effect of inequality on mortality. However, after these extensive controls, the mortality effect of income inequality is not surprisingly modest, but it does offer some "proof of concept" that under certain social, economic, political, cultural and historical circumstances income inequality can affect mortality in some age groups after control (or arguably over-control) for compositional characteristics.

Chapter 6. Comparing the US and Canada

Up to this point in the abbreviated history of the research on income inequality and health, the main empirical observations supporting an association between income inequality and health had been Wilkinson's between-country analysis and the studies conducted within the US. The next important phase of the research on income inequality and health emerged from the continuing collaboration between the group at the University of Michigan and Michael Wolfson and his colleagues at Statistics Canada and the Canadian Institute for Advanced Research. We set out to compare the association between income inequality and population health in Canada and the US. We hypothesized that these two countries offered one of the best between-country comparisons, given their geographical, cultural and economic similarities. Ross and colleagues

compared the association in US metropolitan areas and across cities in Canada[50]. What emerged from these comparisons was that while the strong association across metropolitan areas in the US was confirmed, there was no association between income inequality and mortality in Canada, even though we used virtually identical data definitions and concepts. Initially, this was viewed as the "Canada Paradox". However, newer data suggest that the association between income inequality and health among Australian cities is like Canada's and not like that seen in the US. Figure 8 shows the results from both the US/Canada comparison plus the later data that added results for Australian cities. This is an extremely important observation because it is the first evidence to show that within another rich country other than the US, there is no association between income inequality and mortality.

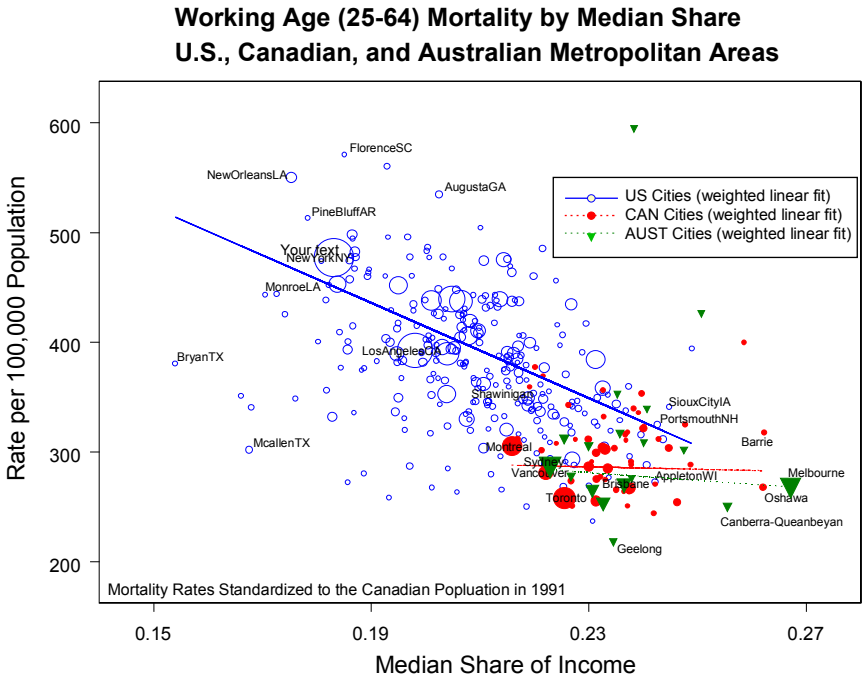


Figure 8. Working Age Mortality by Median Share of Income. US, Canada and Australian Cities

Why Might Canada and the US Differ?

The evidence in Figure 8 above, that there is an association between income inequality and mortality in the US but not in Canada or Australia, has prompted several new lines of research, as well as challenges to the results. The first major empirical challenges were that the original association was artefactual. As noted above, this argument, while logically correct, is empirically insufficient to account for the strength of the observed association in the US. Yet another challenge is that the Canadian data, in some sense, do not have the statistical power to reveal an association even if it were there. This concern is easily addressed. If we consider only

that subset of US cities with income inequality measures in the same low range as the Canadian cities, a significant negative slope remains for the U.S. metropolitan areas (Figure 9), while as before there is no relationship for Canadian cities[51]. The evidence therefore suggests real differences in this relationship between Canada and the US.

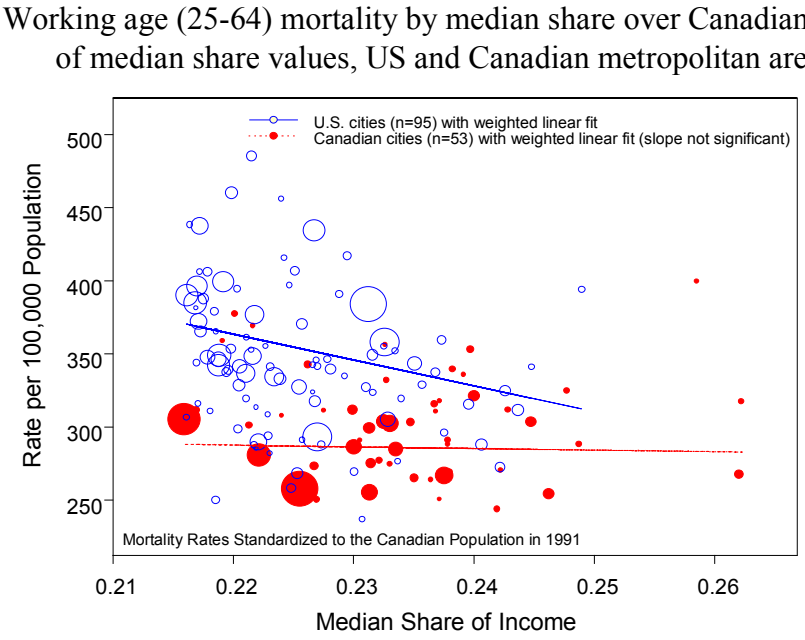


Figure 9. Comparison of US and Canadian Cities over Canadian Range of Income Inequality

Of course, these pieces of evidence of an association provide no guidance regarding causality. We do not know from these data that higher income inequality leads to higher mortality, for example. Indeed, we now actually know the opposite – even if higher inequality led to higher mortality in some societies, like the US, this apparently is not always be the case. The association is not universal so at a minimum some other factors must be involved.

Furthermore, the use of income inequality data does not imply that the distribution of household money income is the underlying factor that should be the focus of attention in trying to understand the observed associations. Rather, income and its distribution may just as well be a marker for a complex of other more deeply rooted factors relating to the extent and character of social inequality in the two countries[52].

For example, some aspects of basic social values, such as trust in government, or tolerance of inequality, may lie behind the differences between Canada and the US – both in levels of income inequality and in levels of mortality. Of course, widespread attitudes of trust in government, which does seem higher in Canada than in the US, is itself the result of social processes, such as investments in schooling and the social formation of children. Thus trust in government can be seen as a marker for a history of material and structural social investments, laws and public policies that are transparently intended to improve the life chances of most of the population. In fact Lynch, et al.[5] show that the countries with the highest levels of overall trust are the Nordic social democratic welfare states, where such social investments have been at the core of public policy for decades and in some places for more than a century[53].

There are several continuing lines of investigation that attempt to better understand why the link between income inequality and health appears to exist in the US but not Canada or Australia[54]. These include:

- Income definitions and the Nature of the Labor Market - In the US, household income may be a better marker for labour market income, while in Canada, with its more substantial tax/transfer system, household income may be too "blurred" to show such a relationship. A recent analysis of multiple concepts of income, income inequality and working age mortality

among US and Canadian metropolitan areas, sheds some light on the effect of labor market inequality on the health of Canadians. Preliminary analyses reveals interesting differences between aspects of labor market participation. For instance, Canada and the US show different patterns of linkages between unemployment and income inequality and also different associations with mortality. In Canada, unemployment appears more strongly linked with mortality, while in the US, it is income inequality. Work continues on these interesting and potentially important questions.

- Universal Health Care - Canada has a universal health care system, while in the US access to health care is significantly constrained at the lower end of the SEP spectrum.

- Taxation and Social Policy – Any health effects of the unequal distribution of incomes generated by the market are blunted by redistributive and other social policies that buffer the effects of market driven inequality by providing a more complete infrastructure that is supportive of better public health.

- Character of the places in which people live - US cities have much more spatially concentrated areas of affluence and poverty than Canadian cities, with associated differential patterns of public goods and urban amenities, and these could be the key factors underlying the difference between Canada and the US.

Canada and the US show fundamentally different patterns. Income inequality may be a significant determinant of health in the US, but this does not appear to be the case in Canada. This does not mean that economic inequality in Canada is unimportant to the health of individuals. Income inequality in Canada does reflect disparities in economic resources at the individual level, and it there is a well-established individual-level relationship between income

and health. But it does not appear that there is any contextual effect of income inequality on health in Canada as there seems to be in the U.S. This is tremendously important, because it suggests that there may be something implicit in Canada's social structure that successfully buffers the adverse health effects of income inequality that have been observed in the US.

This was really the first cogent evidence that while a strong and non-artefactual relationship between income inequality and mortality was certainly possible, the existence of such a relationship was certainly not universal. This may also have important implications for how any observed link between income inequality and health might be interpreted[52]. The "psychosocial environment" approach that emphasizes perceptual processes linked to individual feelings of subordination and relative disadvantage - unlinked to real incomes or material circumstances - implies universality of the health effects of income inequality. The fact that the extent of income inequality is associated with health in the US but not in Canada or Australia would seem to raise serious challenges to the plausibility of a mainly psychosocial interpretation. It seems hard to argue that Canadians perceive their relative disadvantage differently than their neighbors to the south. Much more plausible is that the other social investments in people, places and resources for health has broken the link between income inequality and health.

Chapter 7. Re-examining the International Evidence

Despite these observations of US/Canada differences, the momentum within public health for affirming the link between income inequality and health continued almost unabated with enthusiastic and broad promotion of the idea, often in disregard for the emerging evidence. The theory that income inequality, and its potential influence on aspects of the psychosocial

environment can account for international health differences had become extremely influential for interpreting health inequalities and in a number of countries had been embraced in policy documents focused on strategies to improve population health. Despite the fact that questions had been raised and there were inconsistent findings, the theory that income inequality and its psychosocial effects were critical determinants of population health continued to be indiscriminately accepted and widely promoted[55-57].

It was within this context of the evidence perhaps not being as strong as the pro-income inequality rhetoric, we resolved to revisit the original international observations of Wilkinson. He studied 9 OECD countries with data from the late 1970s and early 80s[28]. We decided to carry out a more complete international examination of associations between income inequality and low birth weight, life expectancy, self-rated health, and age- and cause-specific mortality among countries providing data in Wave III of the Luxembourg Income Study (LIS). The LIS is widely regarded as the premier study of income distribution in the world. We also examined how aspects of the psychosocial environment such as distrust, belonging to organizations, volunteering (all proposed as measures of social capital) and perceived control over one's life circumstances were associated with between-country variations in health. We also included data on belonging to trade unions and the proportion of women elected to national government, as indicators of class relations within the labor market and broader socio-political participation of women.

We found that using more complete and updated income inequality data, there was little evidence for an association between income inequality and population health among rich nations, except for infant and child health outcomes. In discussing our results we argued that it was important to recognize the inherent limitations of interpreting associations based on sixteen, or

fewer observations. To illustrate this point, in Panel (a) of Figure 10 we have selected the 9 countries used by Wilkinson in his ground-breaking 1992 analysis that sparked so much interest in this topic. That study reported a correlation of r=0.86 between more equal income distribution and life expectancy using data for the late 1970s and early 1980s. Panel (a) shows that when we used these same 9 countries, but analyzed data for 1989-92, higher income inequality was associated with lower life expectancy albeit more weakly (r = -0.45).

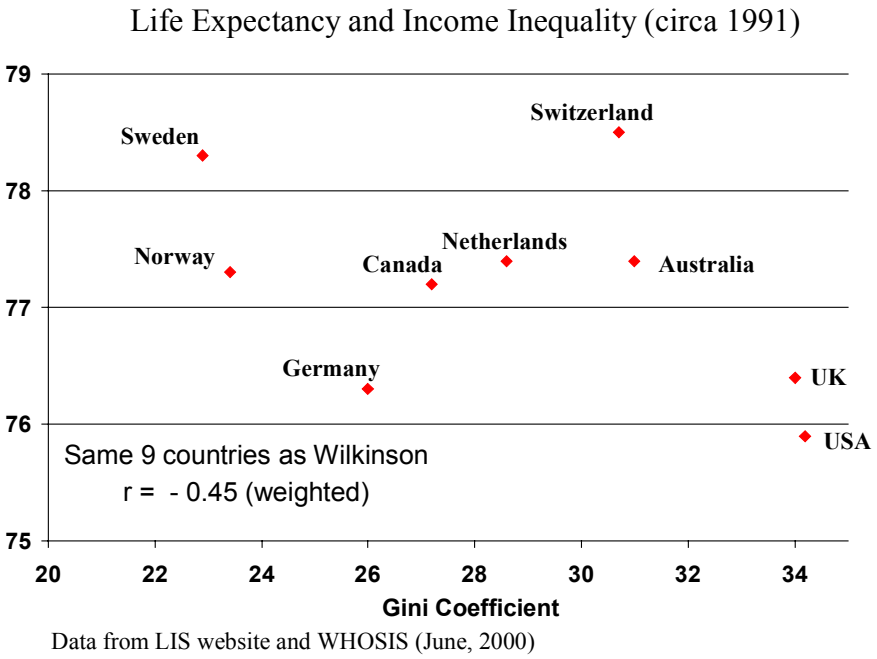
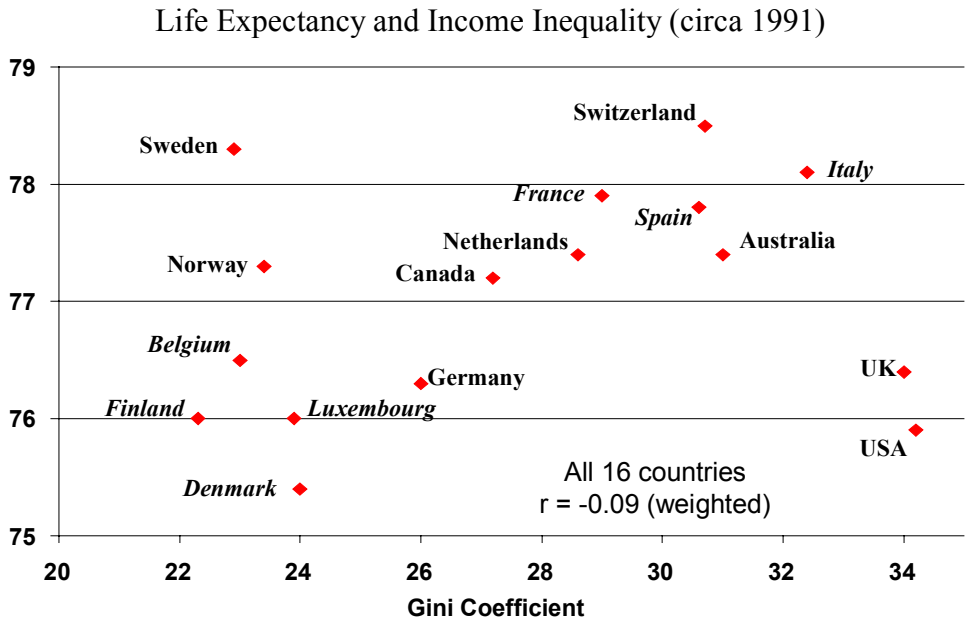


Figure 10. Panel a). Income inequality and Life Expectancy in the Same 9 Countries used in Wilkinson's 1992 Analysis.

Also, recall the argument over the corrected data for Germany that was raised after Wilkinson published his findings in 1992. You can see that compared to Wilkinson's plots, the position of Germany in our data is very different – there are much lower levels of inequality than were reflected in the data for Germany that Wilkinson had originally used. In fact, if Germany was given a value for income inequality like that assigned in Wilkinson's original analysis, we

can come very close to recreating the association reported in his original finding with our data from the 1990s.

However, now that data were also available for Italy, Spain, France, Belgium, Finland, Luxembourg and Denmark, Panel (b) of Figure 10 shows that when these countries were added to the analysis, there was no longer an association between income inequality and life expectancy (r=-0.09, p=0.75). Thus, the discrepancy between our results and Wilkinson's study, was simply that we had the advantage of being able to include more countries with updated data as it became available.



Data from LIS website and WHOSIS (June, 2000)

Figure 10. Panel b) Income inequality and Life Expectancy in Full Sample of Countries.

The addition of Italy, Spain, France, Belgium, Finland, Luxembourg and Denmark, highlights the complexity of attempting to come up with universal theories for what explains variations in population health among rich nations. While not directly comparable to the current

analyses because they were based on within-country differences, Mackenbach[58] and Kunst[59] clearly showed how deciphering variation in the extent of within-country socioeconomic health inequalities across Europe is complicated by between-country differences in the cause-of-death structure, particularly the north-south differences in CHD[60]. Three of the countries we added in Panel (b) - Spain, Italy and France are typical of the pattern in southern Europe - higher life expectancy due largely to lower CHD. The countries added from northern Europe - like Denmark and Finland - have lower inequality, but higher CHD rates and lower life expectancy. Assuming that these north-south CHD and life expectancy differences did not emerge between the 1970s and 1990s, and if the data had been available, it seems likely that Wilkinson's earlier study in 1992 would also have found little association between income inequality and life expectancy for this expanded set of countries.

Cognizant of the dangers of over-interpretation, what can we reasonably conclude from these new international findings? It appears there is a relatively strong and consistent pattern of associations between income inequality and child health outcomes. Higher income inequality was associated with higher infant mortality, low birth weight and mortality aged 1-14 in both sexes. For a country of such vast wealth, the United States has high levels of both income inequality and child ill-health. Associations with infant and early-life mortality largely disappeared when the US was excluded from analyses, but an association with low birth weight remained ($r=0.53$, $p=0.06$) due to high levels of both income inequality and low birth weight in the UK. Associations with mortality above age 65 were the opposite of that predicted by the theory that higher income inequality is automatically bad for health. These negative associations were largely driven by the fact that higher inequality countries like the US and France have

relatively low mortality above age 65, especially for CHD, compared to countries like Finland, Denmark, Luxembourg and Germany.

Importantly for the research on income inequality and health, the age-specific pattern of associations between income inequality and mortality may be consistent with time lags. It is widely recognized that income inequality within many of these countries narrowed or was at least stable after WWII, but has increased markedly since the 1970s (relative to levels in 1950s and 60s) and so it is possible that the associations observed with child health outcomes may be reflected in differences in adult health at some future point in time, as populations exposed to this period of increasing inequality age. Longer-term data on changes in inequality and health are needed to explore this hypothesis but we will revisit this issue in examining trend data within regions of the US.

Some of the strongest arguments in support of the theory that greater income inequality produces worse population health have come from analyses of homicide. In some ways, homicide has been the quintessential example of a cause-of-death that is plausibly affected by the extent of income inequality in light of the breakdown of social cohesion and the negative emotions of distrust and hostility it is theorized to engender in individuals. While income inequality was reasonably strongly correlated with homicide, these associations were almost entirely induced by the US data point. For instance, excluding the US changed the correlation between income inequality and homicide from $r=0.65$ ($p=0.01$) to $r=-0.15$.

According to the psychosocial environment theory, income inequality is associated with health through two main pathways – behaviour and stress. Income inequality was associated with lung cancer, but only among women. On the other hand, it was not associated with cirrhosis – an

outcome with a clearly identifiable behavioral component. Nor was income inequality associated with CHD or diabetes – outcomes linked to both behavior and psycho-neuro-endocrine stress mediation.

While not directly the topic of this paper it was worth noting the other results on the effects of the psychosocial environment also derived from this study. The most important piece of empirical evidence in support of the idea that social capital is an important determinant of population health came from a study of 38 US states[61]. This cross-sectional study showed that levels of distrust and the extent of organizational membership mediated the within-country association between income inequality and mortality. While we used almost identical indicators of social capital to those used in the US study, we failed to find any consistent associations with between-country differences in age- or cause-specific mortality. In fact, one of the stronger correlations observed in these data was the association between higher distrust and lower CHD among both men ($r=-0.63$, $p=0.02$) and women ($r=-0.61$, $p=0.03$). This finding is the exact opposite of what the current income inequality-psychosocial environment theory would predict. An examination of the data plots revealed that people in France, Italy and Spain (lower CHD countries) reported the highest levels of distrust, while those in Finland, Sweden and Norway (higher CHD countries) reported the lowest distrust. While it seems inherently difficult - perhaps impossible - to try to interpret aggregated scores for something like "trust" at the nation level, one could speculate over the reasons for these international differences in the tendency to report things like distrust. If we were to accept that these represent something real, then they are likely the product of quite particular historical, social and cultural forces. It is also possible that the general practice of aggregating individual responses to characterize the psychosocial environment of a place may be inappropriate for between-country comparisons because of their

cultural specificity. Additionally, the individual-level correlates of distrust may vary across countries.

These results do not offer much support for a psychosocial environment theory as a general explanation for health differences between rich countries. Higher perceived control over life circumstances was actually significantly associated with higher CHD – the opposite of what would be predicted by the psychosocial environment theory and the opposite of what would be inferred from individual-level studies. We concluded that it seemed difficult to sustain the theory that income inequality and indicators of the quality of the psychosocial environment explain between-country health differences among these stable, wealthy nations. What theoretically consistent associations did exist were largely limited to child health outcomes and cirrhosis. Our results further emphasized the growing body of evidence that neither an income inequality nor the psychosocial environment theory of health was universally applicable to understanding why some countries have better population health than others.

Our findings were thus consistent with our previous study that compared the US and Canada[50]. While the extent of inequality was strongly related to health differences between US metropolitan areas, there was no association between income inequality and mortality across such areas in Canada. Evidence comparing states and cities within the US has been used extensively to support the income inequality-psychosocial environment theory of population health. It seems likely that the US is the exception, not the rule, and it is possible that evidence drawn from studies within the US has less direct applicability to other wealthy nations.

Chapter 9. US "Exceptionalism"

Two things were beginning to become clearer in the evolving story on income inequality and health. The original international evidence was clearly questionable. More importantly, the fact that rigorous comparisons of the US and Canada showed no association within Canada, could now be more easily reconciled. Far from it being a story about the "Canadian paradox", it appears that the real story is one of "US exceptionalism"[62].

As we showed in our first study of US states in 1996[4], higher income inequality within the US is overwhelmingly associated with more unequal distribution of many potentially powerful determinants of health. This may not be the case in other wealthy countries where there has been more widespread and more evenly distributed social investments in public health-relevant goods and services. There appears to be no necessary association between income inequality and population health – it may depend on the distribution of other health-relevant resources and exposures that exist within a country. For example, low CHD in southern Europe may be related to high prevalence and low social inequality in healthy diets, while the relatively low life expectancy of Danish women is likely related to the high prevalence and low social inequality in smoking[63]. Understanding how different countries generate particular patterns and trends in population health is likely to be historically and culturally contextualized[14,64,65].

It may not be income inequality *per se*, or the quality of the psychosocial environment that drive population health. Rather, what may be most important is the current and historical links between income inequality and the distribution of health-relevant resources and exposures, and how these links have played out over the lifecourse of different birth cohorts[14,66]. Levels of health within a country are the product of complex interactions of history, culture, politics,

economics, and the status of women and minorities, and may not be adequately described by current levels of income inequality or aggregate indicators of the psychosocial environment.

The new results for Australia described above, and the similar results from recently released within-country studies of Denmark[67] and Japan[68], combined with questions about the quality of the evidence underlying the original Wilkinson results, all point to the conclusion that it seems only states and cities within the US that show a clear relationship between income inequality and mortality. There is apparently something rather different about the way income inequality is manifested in the US, and we need to understand more about the economic, social, political and spatial correlates of US-style income inequality.

Having said this, before dismissing the association for other countries completely, there are two caveats worthy of mention. First, most of the this evidence has focused on mortality or life expectancy as the measure of population health and it is possible that there are other important dimensions of health such as psychological morbidity and malaise that are more strongly linked to income inequality. Second, it is important to consider that there may well be other countries where income inequality will be linked to population health because of the particular configuration of health enhancing social investments with income inequality. This may be of particular relevance to developing countries in Central and Latin America or Asia and for the countries of Eastern Europe in economic transition. Levels of income inequality in Russia for instance, far outstrip the US and may well be linked to aspects of population health as they are in the US.

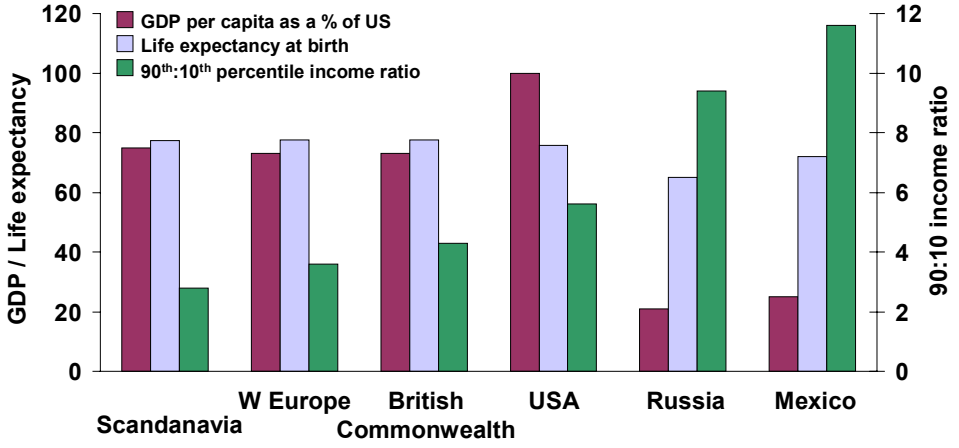


Figure 11. GDP, Income Inequality and Life Expectancy in Selected Regions and Countries

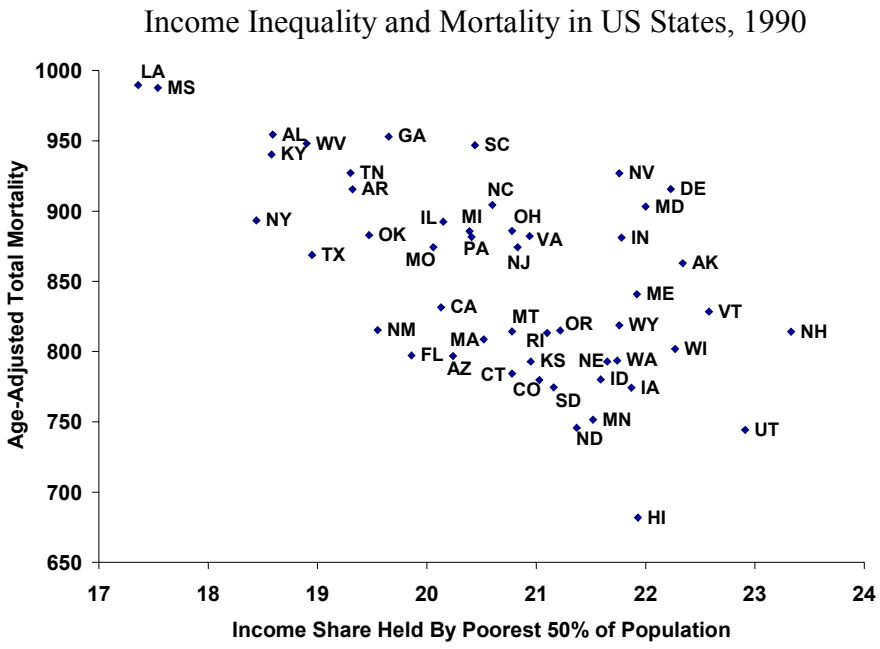
Nevertheless, the link between income inequality and health should not be understood as a necessary relationship, rather it may reflect processes of economic and social development over which policy makers have control. For instance, it is relatively easy to imagine a situation where income inequality was growing over time - driven by market forces - and this was linked with public policies that also fostered the emergence of US-style managed-care health markets, that the ultimate yield for population health would be rather different if those same levels of income inequality were buffered by public policies that ensured universal access to health care. There is no necessary link between income inequality and economic growth. In fact, in recent times the opposite has been shown to be true[69]. Nevertheless, it remains to be uncovered exactly which set of public policies best buffers the health impacts of income inequality and this is an important

area of future investigation that has enormous practical implications for policy development and differs markedly from the policy implications that would arise from the view that the effects of income inequality are an inevitable consequence of humans' creating social hierarchies[70].

Chapter 10. Regional Mortality in the US: A Role for Income Inequality?

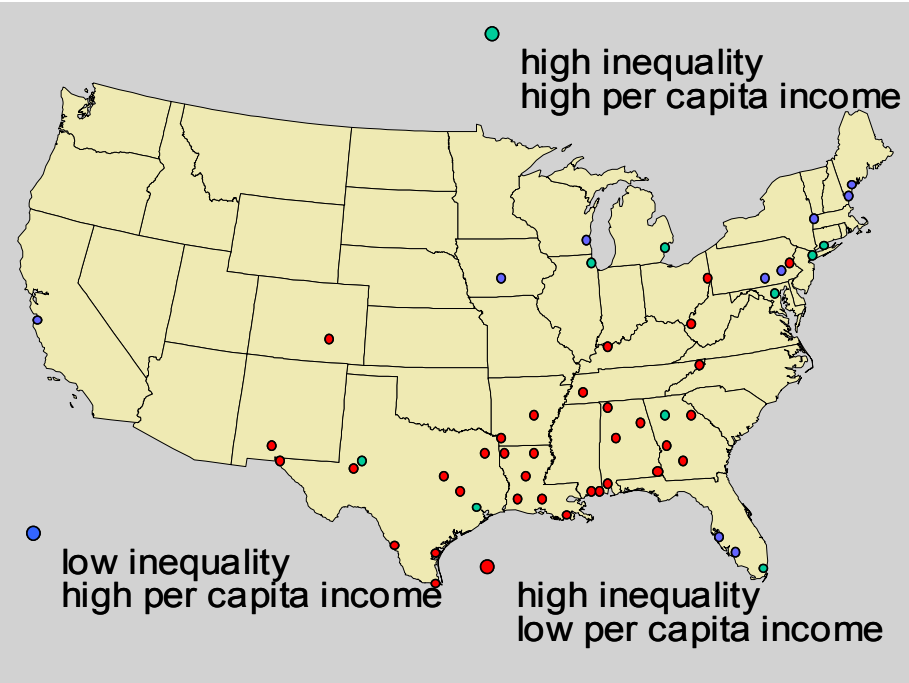
Given this background, we can now turn to the other issue posed in the title of this paper with more certainty that the question is even worth asking. Is income inequality associated with regional mortality differences in the US? Even the very first studies of US states showed an apparently strong regional pattern to the link between income inequality and mortality. Figure 11 shows that the most unequal, high mortality states were predominantly in the South – Louisiana, Mississippi, Alabama, Kentucky, Georgia, W. Virginia, etc.

Figure 11. Income share and mortality, US States, 1990



The analysis of US metropolitan areas is somewhat less clear-cut but there is certainly some evidence that metropolitan areas in the south were in general more unequal and had higher mortality (See Figure 8). Furthermore, if we combine information on both low average income and income inequality, the places that receive the "double-whammy" of lower average income and higher income inequality are overwhelmingly in the southern US.

Figure 12. Income Inequality and Per Capita Income, US Metro Areas, 1990



So, at first examination there does appear to be some evidence for a regional component to overall links between mortality and income inequality, in that southern US states and metro areas have lower average income, higher income inequality and higher mortality. In addition, it appears that there are regional differences in the strength of association between income inequality and mortality. Figure 13 shows the associations between income inequality and mortality (net median income differences) within each Census region of the US. While there is a

statistically significant association between income inequality and mortality in all regions of the US, it is much stronger in the Midwest and Northeast than in the West. Most interestingly the weakest association was among the Southern metropolitan areas. So while an important component of the overall national picture derives from the position of southern states and metro areas in relation to the others, within the South itself there is a much weaker link between income inequality and mortality.

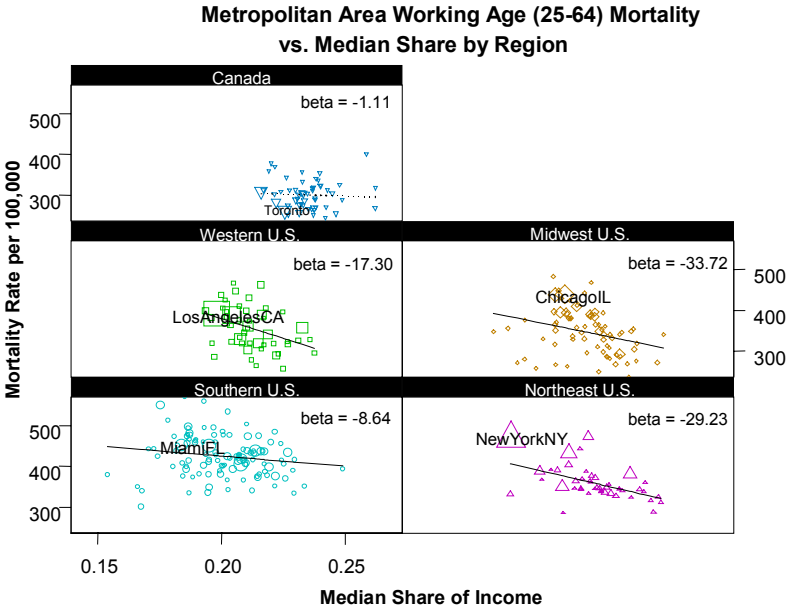


Figure 13. Associations between Income Inequality and Mortality across Regions of North America, 1990

The Southern region is recognized as generally having the worst population health profiles in the US, although there is obviously a great deal of underlying heterogeneity by place and outcome. Nevertheless, these data suggest that for the region of the US with the worst population health profiles, the extent of income inequality (which has a similar range as nationally) within that region does not appear to be as strongly linked to variations in mortality

within the region as it is in other regions of the US. This cannot be simply explained by a

Table 1. Year 2000 Population Distribution[1] and Median Income[2] by Race/ Ethnicity, and 1989 Income Inequality[3] by Race/ Ethnicity, US Census Regions

	Northeast	Midwest	South	West
% US Population	19.0	22.9	35.6	22.5
% White	79.1	85.0	74.1	72.0
% Black	12.2	10.6	19.5	5.5
% Hispanic[4]	9.8	4.9	11.6	24.3
Median Income	45,118	44,647	38,402	44,759
White	47,205	46,617	40,879	44,592
Black	30,426	30,053	29,778	36,975
White/ Black	16,779	16,564	11,101	7,617
White/ Black Ratio	1.56	1.55	1.37	1.21
Income Inequality	0.45	0.43	0.45	0.44
White	0.44	0.42	0.44	0.44
Black	0.46	0.48	0.46	0.44

[1]Source: US Census Bureau, Profiles of General Demographic Characteristics, 2000.
[2]Source: US Census Bureau, Historical Income Tables from the Current Population Survey (2000 US dollars).
[3]Source: Authors' calculations based on unpublished 1990 data from the US Census Bureau.
[4]Note: Hispanics may be of any race.

narrower range of income inequality. Thus, there is some evidence that there may be region-specific compositional and contextual factors that figure into the association between income inequality and mortality that require further investigation. Table 1 shows some basic demographic and economic differences between these US regions. It is clear that there are different race/ethnic compositions of minority groups. These compositional differences and the way income inequality is expressed across these different groups within regions may be important to better understanding the regional differences in the strength of the association.

The Temporal Component – Regional Mortality Trends and Income Inequality

The suggestive evidence presented above is of course taking a cross-sectional view. It is worth noting at the outset that in the history of research on income inequality and health there have been very few longitudinal studies. In the US, only four studies have included a longitudinal component. Kaplan et al., in 1996 showed that levels of income inequality in 1980 were associated with slower declines in state-level mortality from 1980-90. More recently, Mellor and Milyo[32] examined time-lagged trends of income inequality and mortality from the 1950s onward and found generally negative but somewhat mixed results, depending on the time-lag employed and the selection of control variables. In short, we find it somewhat difficult to know what to conclude from the Mellor and Milyo analyses as they rely on their own set of data limitations and assumptions that may or may not provide informative results. Blakely and colleagues[71] evaluated the lagged effect of state-level income inequality on individual self-rated health and found that income inequality measured 16 years earlier had a stronger effect than did inequality measured contemporaneously on those 45 years and older, after adjustment for race and individual income. However, the results for those ages 15 to 44 were inconclusive and the authors concluded that there might be insufficient variation in state-level income inequality over time to detect significant lag effects. In unpublished analyses, Deaton and Paxson argued that neither trends in income or income inequality showed much resemblance to declining age-specific death rates in the US from 1950[72]. Thus, the literature so far on understanding mortality trends is mixed.

Within a broader conceptual framework, David Leon and George Davey Smith have argued cogently for the importance of thinking about time lags between relevant exposures and outcomes[73], and for how our knowledge of individual-level risk factors might be profitably used

to interpret temporal trends in population health[14,15,74,75]. While some of these ideas are not really new - techniques such as birth cohort analysis have been used for decades[76-78]- it can be argued that modern epidemiology is dominated by the identification of individual, proximal risk factors for disease. It is important however, that we not loose sight of the fact that one of our fundamental tasks as epidemiologists is to understand why certain diseases wax and wane in different populations and population sub-groups over time. This involves understanding the dynamic interplay of individual risk and population level trends in particular diseases. Indeed, discussion and debate still occurs on the exact contributions of different factors to the 19th century transition from infectious to chronic diseases that occurred in wealthier countries[79-82]; what factors explain the precipitous rise and equally impressive fall in coronary heart disease in many countries[83-85]; and what the real contribution of traditional risk factors such as smoking, lipids and hypertension were to trends in heart disease[86,87]. A recent example are the discussions over the rise and fall of peptic ulcer in the population – its association with *Helicobacter Pylori* infection and perhaps interactions with other factors such as social stress and diet[88-92]. The point here is that there seems something rather fundamental about being able to link our knowledge of risk exposures at the individual and social level with what we observe in population level health trends over time.

In the US in particular there is very little attention among epidemiologists, to examining population-level trends in different diseases. My informal polling of Masters and PhD students in epidemiology is that they have been taught very little about disease trends. In fact, if I ask them to write down the major risk factors for coronary heart disease (CHD) and then for stroke, this proves to be a fairly easy task and they come up with rather similar lists. Indeed, it is very common to see CHD and stroke combined into one outcome - cardiovascular disease - because

of these apparent similarities in individual risk factors. However, if one examines the long-term trends in these two conditions since the turn of the century, then they look dramatically different, with an unabated decline in stroke - mainly from haemorrhagic stroke - but for CHD, a sharp rise in the 1920s, to a peak in the 1960s and since then a rapid decline of more than 50%. There are two important points here. First, it is necessary to pay attention to the temporal component of links between risk factors and disease outcomes – this so-called "lifecourse approach" is beginning to be more fully articulated[93] and can be applied at both the individual and population levels. Second, there are good reasons to examine outcome specific trends, in addition to overall indicators of population health. So while trends in all-cause mortality or life expectancy or DALYs or self-rated health may be informative for some purposes, they also may obscure considerable heterogeneity that may be exploited to better understand the dynamic linkages between changing environments, particular risk exposures and different types of health outcomes. So in this view there is something fundamental about trying to understand trends in different types of population health indicators – it is some of the most basic "stuff" of population health.

In thinking about how income inequality – a population-level characteristic – might be potentially linked to regional differences in health in the US we begin by displaying 30-year regional trends in some selected causes of death. Figure 14 shows the designated census regions of the US.

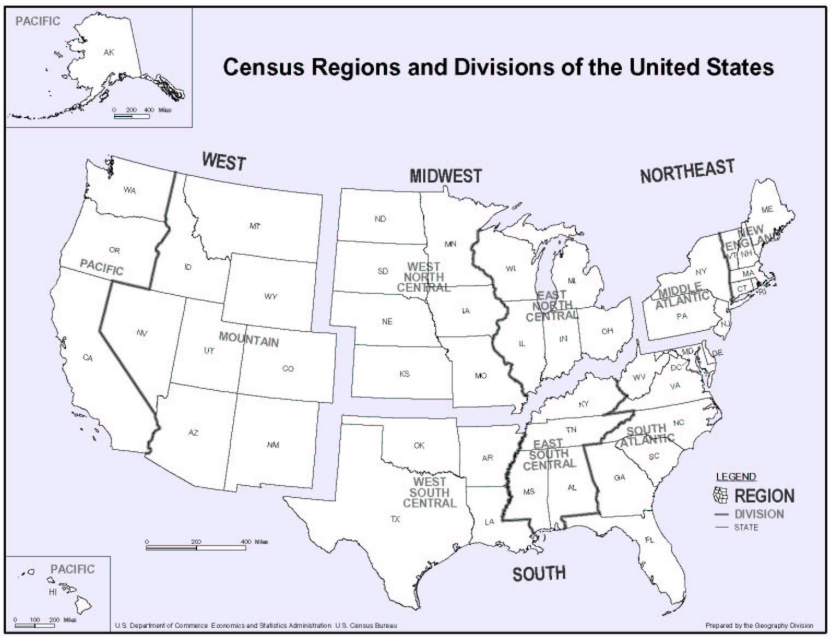


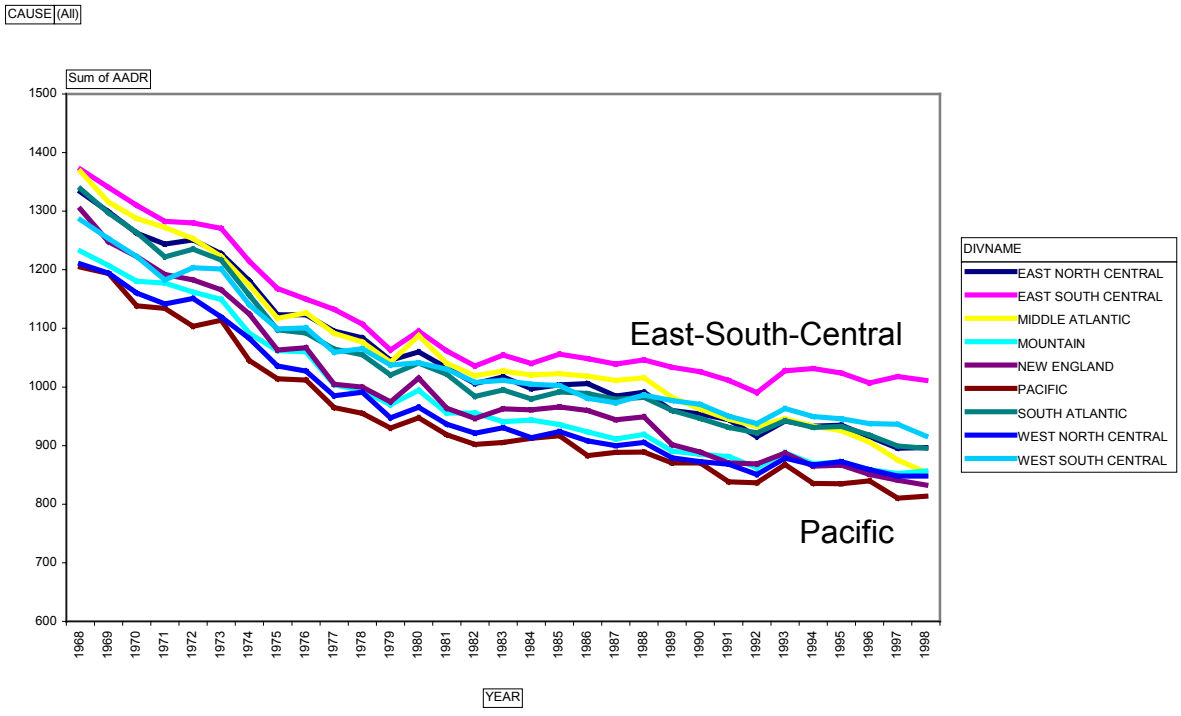
Fig 14 Standard Census defined US Regions

The series of figures that follows shows trends in all-cause mortality, ischemic heart disease (IHD), stroke, lung, breast and prostate cancer, suicide, homicide and diabetes across these 9 regions. Of course, we could have shown state-level trends or perhaps even different theoretically driven groupings of states, but for the purposes of this presentation and simplicity we chose to show the trends in the 9 standard Census regions.

As expected, trends in all-cause mortality over the last 30 years (Figure 15) show that every region of the US has improved substantially, but with some widening of regional inequality, whereby there is now a larger gap between the highest and lowest mortality areas - the East-South-Central and Pacific regions. Between 1968 and 1998 absolute regional differences increased from 168 to 198 deaths per 100K, while relative regional inequality

increased from 1.14 to 1.24. Nevertheless, what is striking about these trends is the overall stability of the relative positions of the regions. The Pacific region has demonstrated the healthiest mortality profile and it has done that for more than 30 years, perhaps because of something in the context of the Pacific region and/or perhaps because of the composition of the population in the Pacific region. In contrast the opposite is true in the East-South-Central region and this is the area with the highest concentrations of higher income inequality and low per capita income.

Figure 15. 30-year Trends in All-Cause Mortality, US Regions.



There is evidence of slower declines in all-cause mortality in the West and East-South-Central regions from the early 1980s, that may coincide with the period of widening income inequality,

but this region of the US is also where the links between income inequality and mortality are weakest. Another feature of these trends is that some regions such as the Middle Atlantic shifted relative position, nevertheless, the over-riding impression is that knowing where a region started in 1968 tells you a lot about where it is likely to be relative to other regions 30 years later.

This relative stability in regional trends is also clear when examining cause-specific 30-year mortality trends. The Middle Atlantic region has had historically the highest levels of IHD and the Mountain region the lowest. In 1968, they differed by 186 IHD deaths per 100K, corresponding to a rate ratio of 1.5. In 1998, they still hold those same positions but with

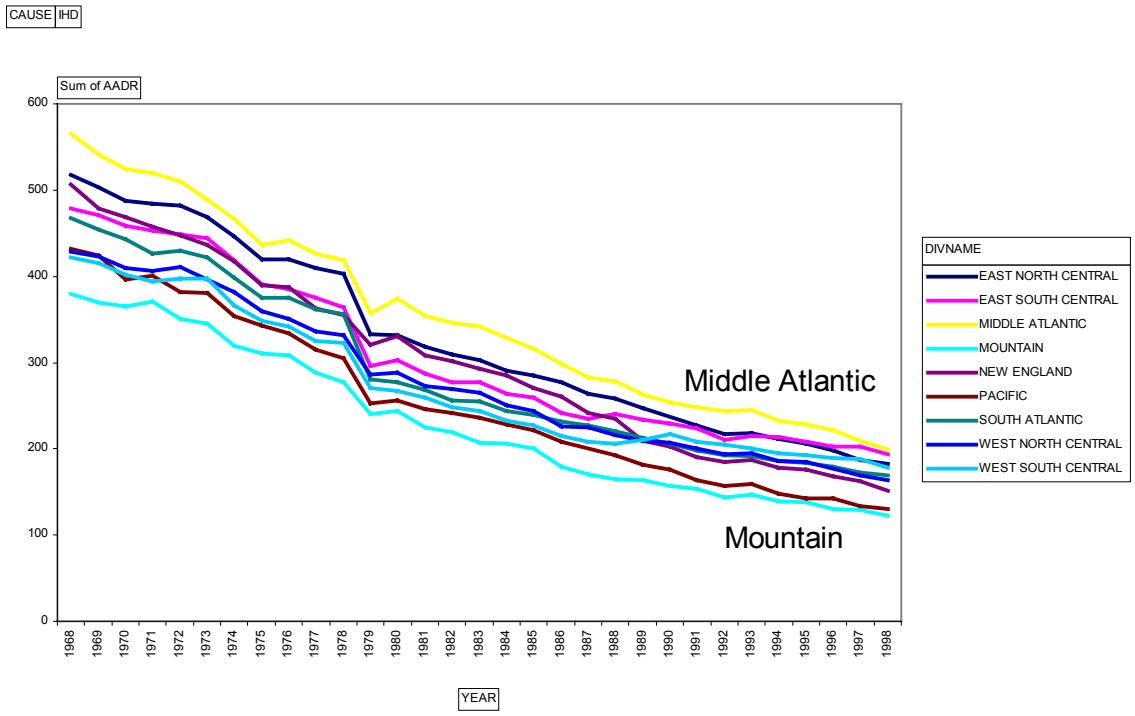


Figure 16. 30-year Trends in IHD Mortality, US Regions.

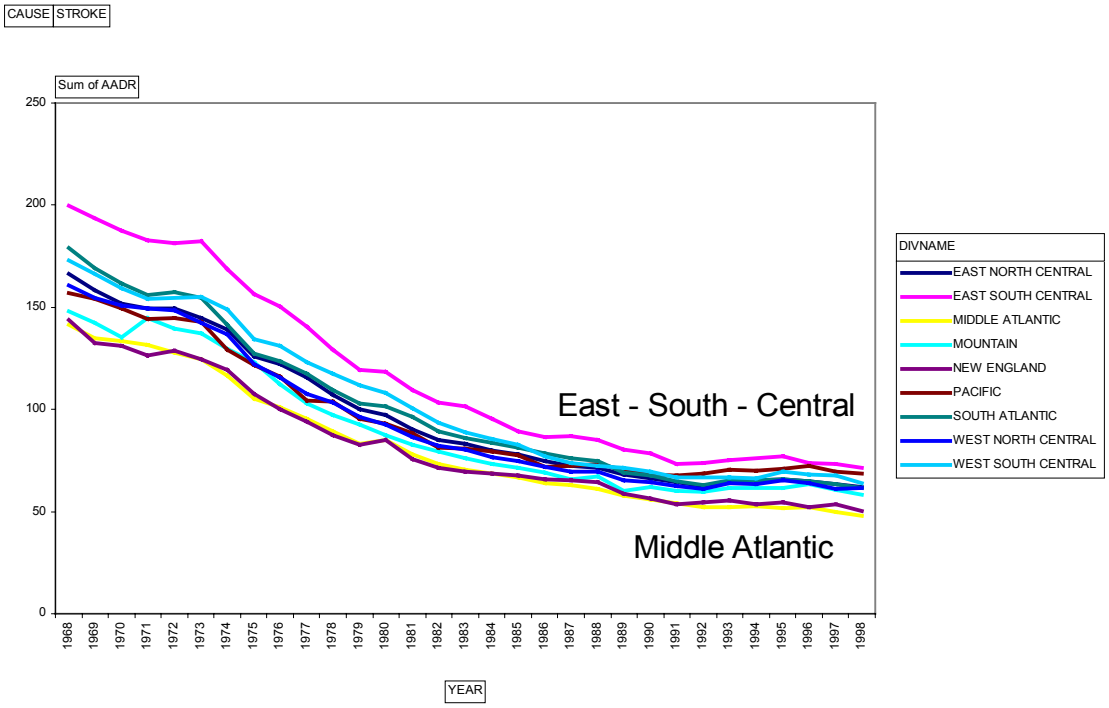
narrower absolute differences of 77 IHD deaths per 100K and similar relative inequality of 1.6. However, within these relatively stable patterns, New England shows strong improvements over time from 3rd worst to 3rd best in 30 years, while the West-South-Central reverses its declines in

IHD in the late 1980s and for a period of about 3 years is the only region in the US to show increasing IHD death rates. So over 30 years these two regions swap their relative positions.

As mentioned before, stroke - especially hemorrhagic stroke - has declined spectacularly since the 1900s and that decline is still evident from 1968-1998 with especially steep declines up until the early 1980s with the East-South-Central region experiencing declines of 50% in the 15 years between 1968 and 1983. (Figure 17) This is in stark contrast to the generally slower declines in overall mortality and speaks to the value of examining trends in different causes. Now cause-specific differences across regional trends also begin to emerge. For stroke, it is the Middle-Atlantic and New England regions that have had the historically lowest rates - almost the opposite pattern to IHD, where the Middle Atlantic had the highest rates. What is striking about the trends in stroke is the narrowing of absolute regional inequality and despite the enormous secular changes in stroke over time, the relative positions of the US regions stay rather stable.

Again, knowing something about initial mortality conditions says a lot about where that region will be 30 years later and implies that whatever distinguishes the initial mortality differences between regions - which also differs by cause - still distinguishes them 30 years later. If it is initial and/or historical levels of income inequality that help determine these starting conditions then it seems to do so cause-specifically because the relative orderings of the regions differ according to cause of mortality. It also implies that regional changes in income inequality should be reflected in changing mortality trends. It seems already evident that this may argue against any simple understanding of how income inequality - which by any account has risen over this same time period across all US regions - may have expressed itself in these mortality trends.

Figure 17. 30-year Trends in Stroke Mortality, US Regions.

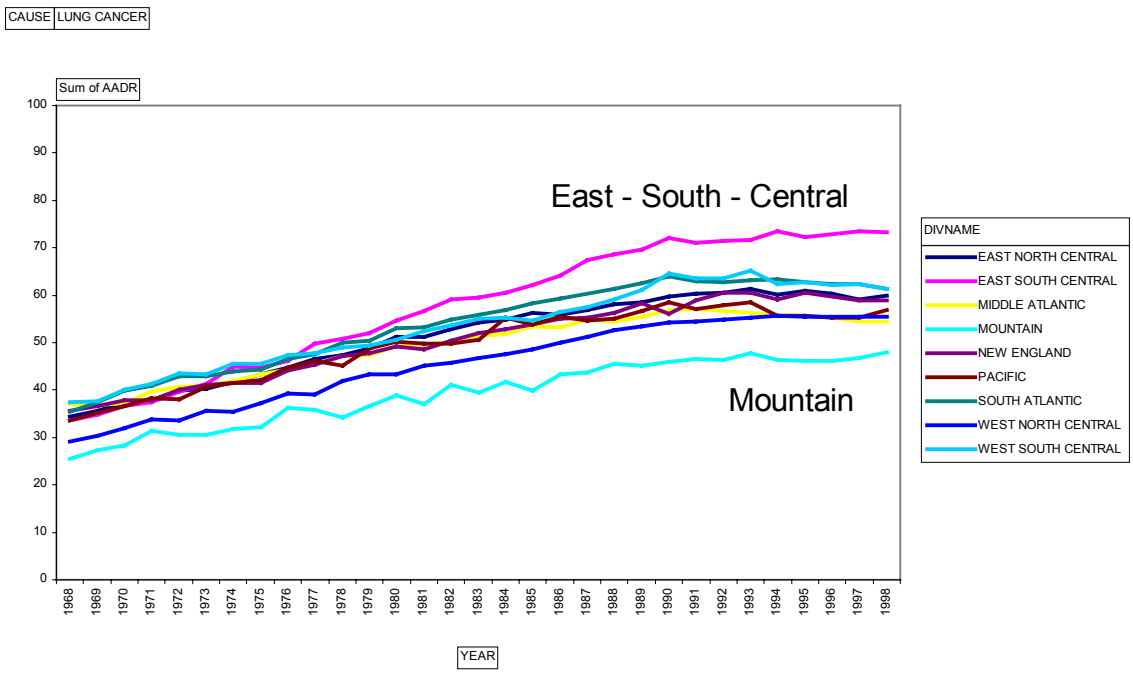


Now we turn our attention to a cause of mortality that shows an increasing 30-year trend in all regions – lung cancer – that has a clearly identifiable behavioral component. Figure 17 shows regional lung cancer mortality trends that demonstrate widening absolute and regional inequality between 1968 and 1998 that logically follows the time-lagged rise in smoking prevalence from its rise during World War 1, to its peak in the mid 1960s shown in Figure 18. In 1968 (40-50 years after the first cohorts took up smoking in large numbers), there was a relatively tight clustering of lung cancer rates across regions, with the exceptions being substantially lower rates historically evident in Mountain and West-Nth-Central regions.

Over 30 years the regional disparity increased enormously, with the East-South-Central and South-Atlantic showing the largest increases in lung cancer mortality. These are also unsurprisingly, the main tobacco producing regions of the US. However, whatever was initially

protective (contextual and compositional) for the uptake of smoking and of later lung cancer mortality in the Mountain and West-North-Central regions, it continued to generate the lowest rates of lung cancer over the next 30 years. It is possible that regional analyses of income inequality might reveal that these were the places that experienced the largest differentials in changes in income inequality over this time period – those analyses are underway – but it seems more likely that a simpler (and yet in itself complex) explanation exists related to the differing historical roles of tobacco use in the economies and cultures of these contrasting regions – the tobacco producing areas of the Southern US vs the more religiously and socially conservative Midwest and mountain areas.

Figure 18. 30-year Trends in Lung Cancer Mortality, US Regions.



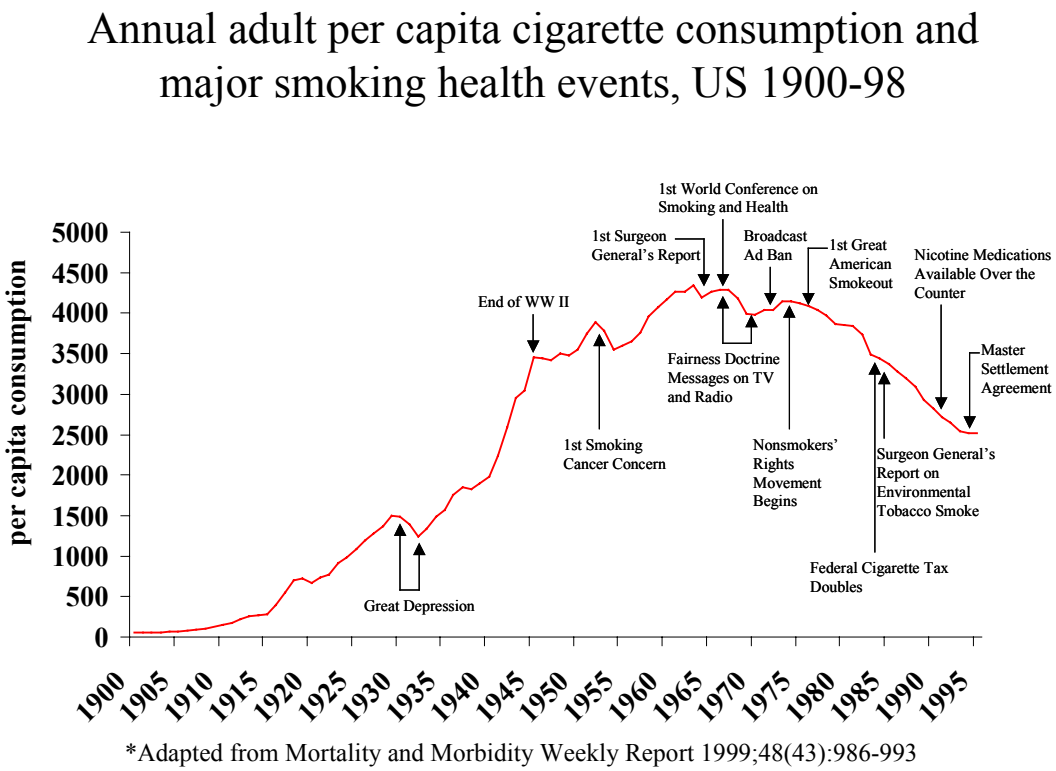


Fig 19. Historical Points in Cigarette Consumption in the US, 1900-1998

Finally, Figures 20-23 show 30-year mortality trends for four outcomes that demonstrate somewhat more stable secular trends - albeit with some large short term fluctuations - prostate and breast cancer, suicide and homicide. Also, note the regional heterogeneity by cause of death, with the Mountain region having the lowest breast cancer rates but the highest prostate cancer and suicide rates. Some of the strongest arguments in support of the theory that greater income inequality produces worse population health have come from analyses of homicide. As mentioned above, homicide has been an important part of the argument for the plausibility of links between income and health, through the breakdown of social cohesion and the negative emotions of distrust and hostility, it is theorized to engender in individuals[37] and importantly, the

fact that the time lag between exposure and outcome is likely to be much shorter than for chronic diseases. These data suggest that any changes in income inequality between 1968 and 1998 do not produce any obvious trend changes in homicide mortality in any region of the US. In some regions homicide is rather stable, while in others it fluctuates throughout the time period that income inequality was consistently rising.

Figure 20. 30-year Trends in Breast Cancer Mortality, US Regions

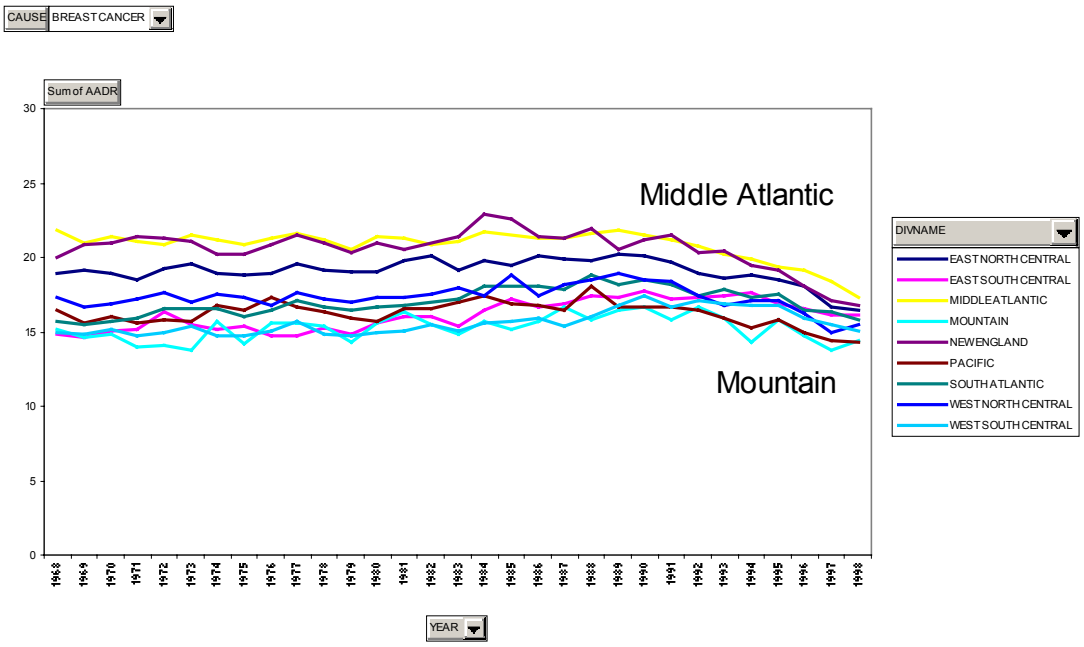


Figure 21. 30-year Trends in Prostate Cancer Mortality, US Regions

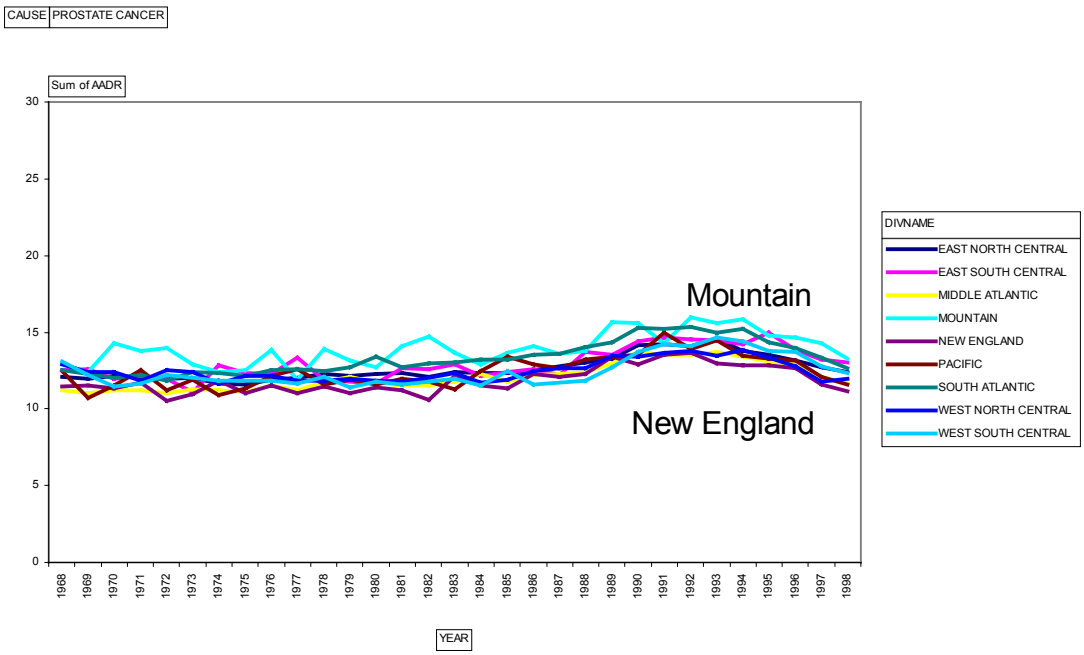
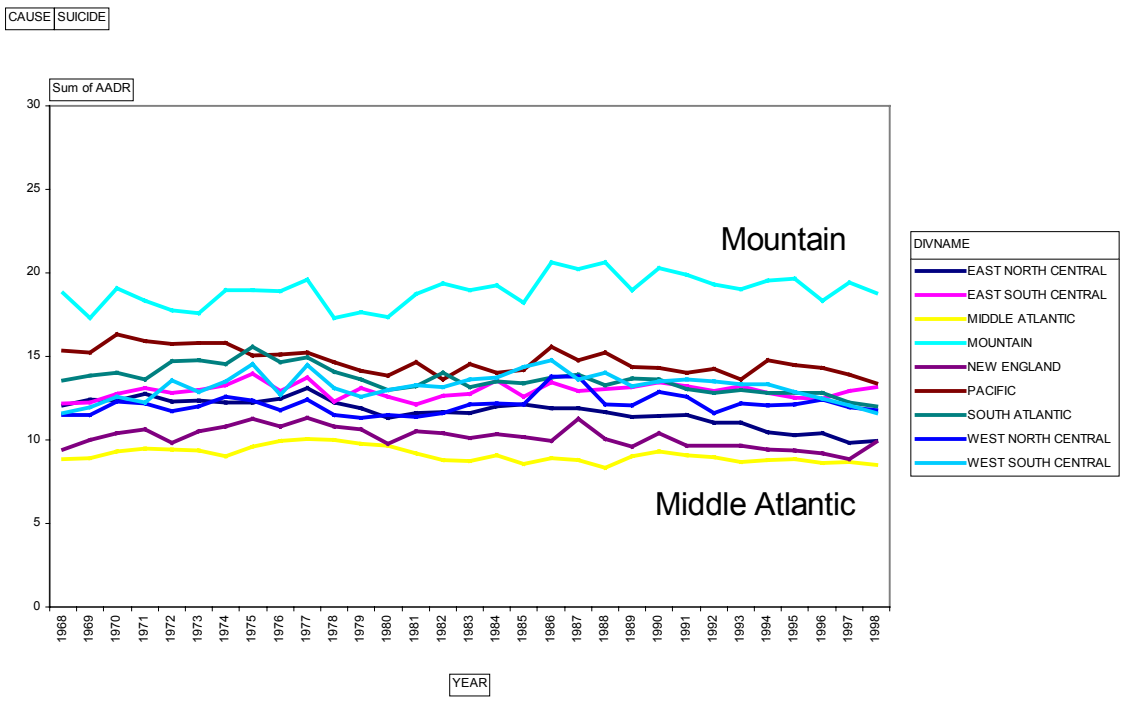


Figure 22. 30-year Trends in Suicide Mortality, US Regions



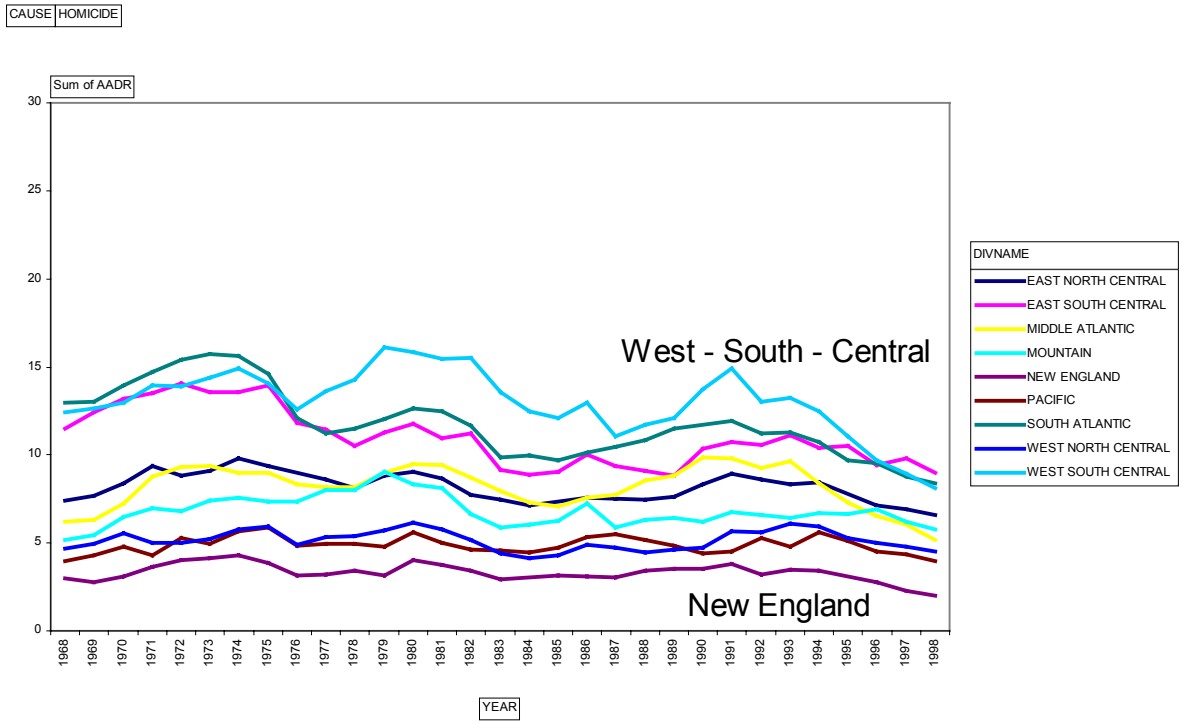


Figure 23. 30-year Trends in Homicide Mortality, US Regions

Examination of these disease specific regional trends suggests a good deal of heterogeneity across causes. The relative rankings of the regions by cause also shows no clear patterns, whether the secular trends are stable, increasing or decreasing. Perhaps the most enduring impression is the cause-specific stability of regional differences over time - in general, a region's relative position in 1968 appears to be the strongest determinant of its position in 1998. This is not to say there are no exceptions and it may be interesting to examine some of the more dramatic shifts in regional trajectories over time – such as the upturn in IHD deaths in the West–South–Central region in the early 1980s.

What can be said about the potential for income inequality to influence these disease specific trends? First, we chose to examine regional trends during the period 1968-1998 because this is precisely the period when levels of income inequality rose sharply in the US - at least relative to post-war levels. This assumes that there is no time lag between exposure to income inequality and its effects on mortality trends. This may be more plausible for some outcomes but not others. Nevertheless, most of the accumulated evidence on the health effects of income inequality has ignored specific hypotheses about such time lag effects. If historical, starting levels and changes in income inequality are important determinants of these mortality trends, it seems difficult to come up with a straightforward hypothesis for how it could account for the different secular trends, relative regional stability over time and the heterogeneity of the ordering of the regions by cause. There would appear to have to be a number of different mechanisms and time lags involved in producing these patterns, which do not fit easily into a notion that levels of income inequality, *per se*, are driving all these cause-specific mortality trends.

Until Census 2000 figures are available, we do not have detailed trend data on regional income inequality. Certainly, the rise in income inequality experienced in the US as a whole from the mid-1960s onwards was evidenced in every state and region to a greater or lesser extent. A very recent report based on the Current Population Survey (CPS) by Bernstein et al.,[94] has shown some variability in changes in the "top-to-bottom ratio" (incomes of the top 20% vs incomes for the bottom 20% of the population) across regions of the US for the period 1978-2000, which corresponds to the period of the largest rise in inequality. The largest increases in this measure of income inequality were observed down the eastern seaboard of the US - in the Middle and Southern Atlantic states and New England. There is no obvious association between the starting levels of income inequality in 1978 and the changes experienced over the next 20

years. For instance, in 1978 New England had the lowest ratio at 6.3 and then experienced the largest absolute and percentage increase to 9.0 (46%). In contrast, the highest levels of inequality in 1978 were in the West and East-South Central region (which generally has the poorest population health profiles), but they experienced some of the smallest increases from 1978-2000.

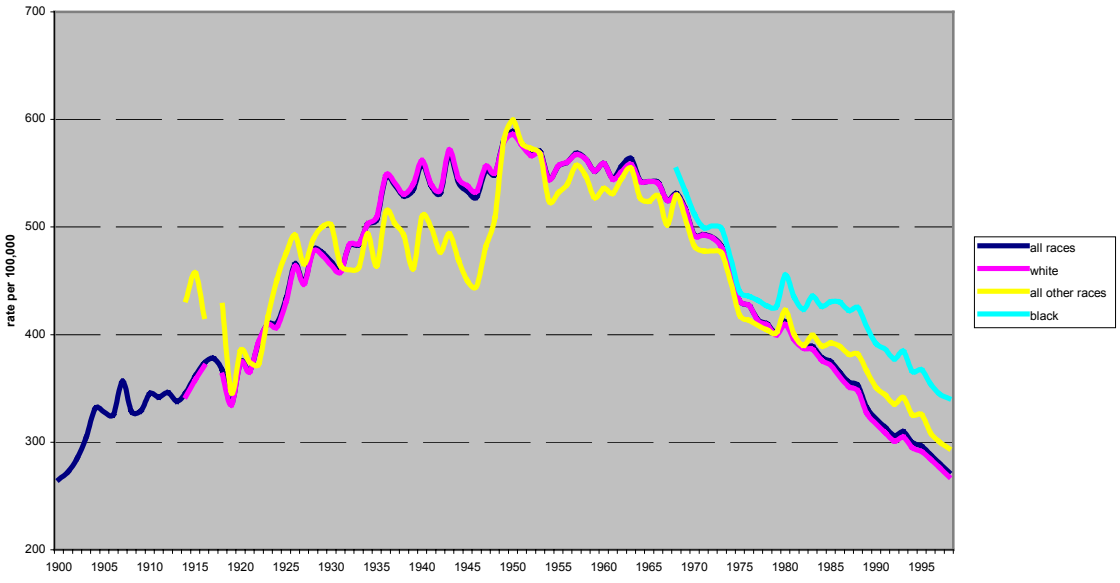
Table 2. Changes in regional income inequality in the US, 1978-2000

Division	Top-to-bottom ratio 1978-80	Top-to-bottom ratio 1998-2000	Absolute and (%) change in top-to-bottom ratio
EAST NORTH CENTRAL	6.5	8.7	2.2 (34%)
EAST SOUTH CENTRAL	8.3	10.1	1.9 (22%)
MIDDLE ATLANTIC	7.1	10.4	3.3 (46%)
MOUNTAIN	6.8	8.6	1.8 (26%)
NEW ENGLAND	6.3	9.0	2.6 (43%)
PACIFIC	7.5	9.5	2.0 (27%)
SOUTH ATLANTIC	7.8	10.4	2.6 (33%)
WEST NORTH CENTRAL	6.6	8.1	1.5 (23%)
WEST SOUTH CENTRAL	8.5	10.2	1.8 (20%)
Grand Total	7.2	9.3	2.1 (29%)

National Trends in CHD and Income Inequality over the 20th Century

For the purposes of this paper, it may also be informative to examine longer term national trends in income inequality with trends in one of the most important diseases of the 20th century – heart disease. As the analyses above suggest, regional patterns of IHD appear rather stable over the 30 years between 1968 and 1998, but it is difficult to gain an assessment of the true regional differences in income inequality with the data at hand. In any event, the trend data on income inequality (shown in Table 2) suggest that if changes in regional income inequality do affect regional mortality trends, the associations are complex, so the somewhat more simple national date are a useful place to start, especially in trying to investigate time lags. Heart disease is a good example for this sort of trend analysis, because it is probably the most studied disease in human history and a great deal is known about its causes. Smoking, blood lipids and hypertension have merged as the three main risk factors for heart disease. While all these factors

Figure 24. Race-specific heart disease mortality, US 1900-1998



clearly have complex social and biological causes of their own that are worthy of explanation, there is little doubt that they play a major role in causing heart disease.

Figures 24 and 25 show the race and sex-specific rates of heart disease from 1900-1998. The designation for "heart disease" is deliberately broad because definitions and diagnoses have changed over time (See Appendix 1 for ICD codes). We have used a broad definition of heart disease that while not directly comparable to what we know today as coronary heart disease (CHD), does provides reasonable comparability across time – and that is more important for these analyses.

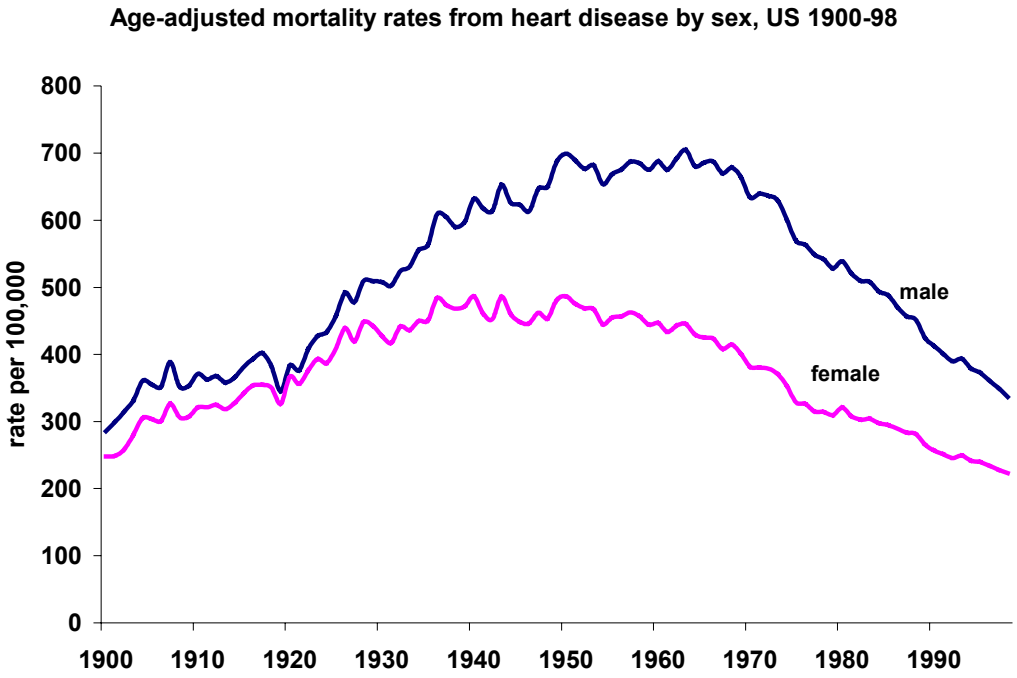


Figure 25. Sex-specific heart disease mortality, 1900-1998, USA.

Both Figures 24 and 25 show that in some ways we have come full circle so that current rates of heart disease are now back to the levels observed at the turn of the century – 265 in 1900 and 272 per 100k in 1998. This in no way lessens the importance of this disease as it still affects

substantial numbers of people, but its equally rapid rise and fall is one of the most prominent features of population health in the 20th century, not just in the US but in many other developed nations as well[95,96]. While it is clear that traditional risk factors such as smoking, high fat diet and hypertension, and advances in medical care have both played an important role in explaining this mortality trend[86], we still do not know the precise ways in which risk factors combined to produce the epidemic of heart disease[97].

One important feature of Figure 24 is how the decline of heart disease has diverged for blacks and whites during the mid 1970s. From 1975 to 1990 the decline in rates of heart disease for blacks was significantly slower than for whites – perhaps even stalling, but even this is hard to match with simultaneous income inequality trends, which continued to rise after the 1990s, when the rates of decline for blacks and whites were virtually identical. Figure 25 clearly shows the increasing sex ratio in heart disease from the rise of the epidemic in the 1920s. Whatever caused the rapid increase in heart disease did so in men to a much greater extent than in women. This likely reflects different biological predispositions combined with different sex distributions of the main risk factors[86]. This means that if income inequality is implicated in these divergent sex ratios, then it would probably have to affect the sex distributions of the risk factors, so that rising income inequality would be more potent in its effects on risk factors like smoking and fat consumption for men than for women. Given these race and sex-specific patterns of heart disease over the century, how do they coincide with trends in income inequality?

Figure 26. Income Inequality, US 1913-1998

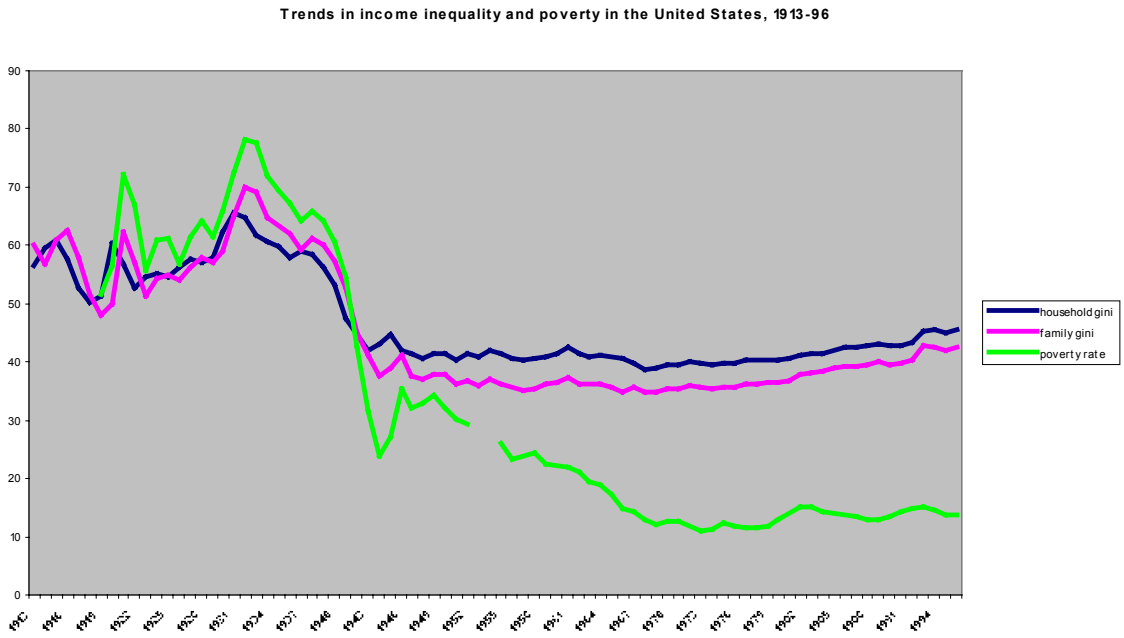
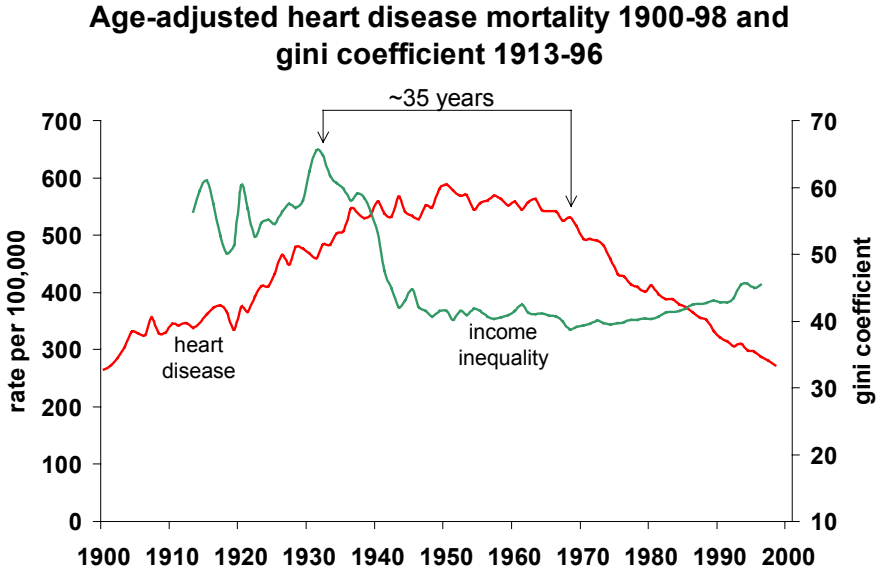


Figure 26 shows trends in income inequality from when reliable income data became available in 1913. Two features are important. First, the really big income inequality story in the 20th century seems to be the rise during the inter-war period and the depression, followed by massive declines during and after World War II. Second, after World War II, income inequality has been relatively stable - at least as measured by the gini coefficient relative to earlier periods - so that the recent increases that have drawn so much academic and popular attention are rather modest compared to the huge declines witnessed after the late 1930s, that helped establish the economic conditions for the baby-boom generations. Perhaps this also helps in understanding why changes in income inequality from the late 1960s appear to have no simple association with disease trends. If income inequality affects population health, these changes were rather modest when compared to the historical record.

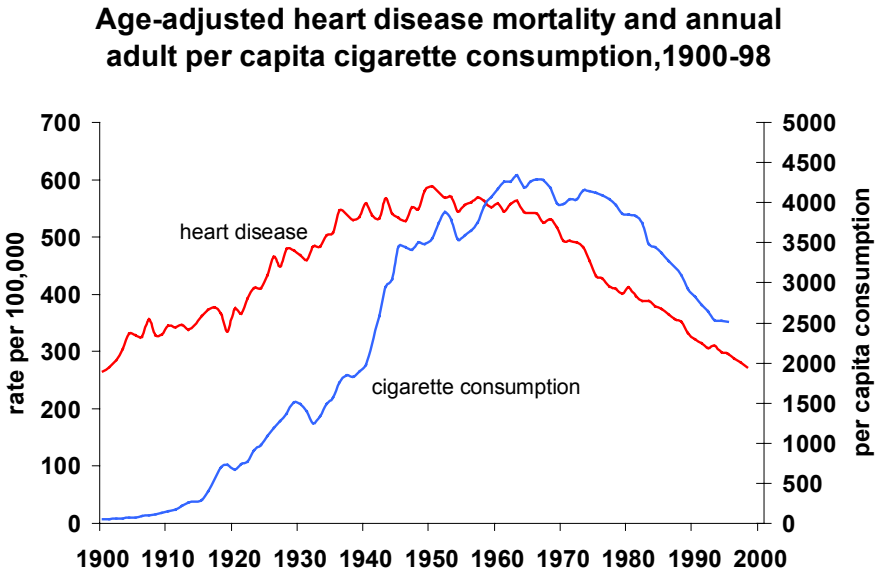
So, if income inequality does play an important role in determining levels of population health, then it is the much larger changes from the 1930s to the mid 1940s that should be discernible. Additionally, given the evidence on the rise of late 19th century wealth inequality it seems reasonable to assume that income inequality was also rising during the later part of the 19th century[9]. Thus, if a 30-35 year time-lag were imposed on the link between exposure to income inequality and heart disease mortality, it might be possible to build a story of how the rise from the late 19th century to a peak in the early 1930s, followed by massive declines up to the late 1940s affected the subsequent rise and fall in heart disease. Overlaying the trends in income inequality and heart disease (Figure 27) with a 35-year time lag shows that the decline in income inequality fits reasonably well with the decline in heart disease. We do not know precisely what happened to income inequality prior to 1913, but it is plausible that it rose from the 1850s and was the stable from the 1890 to the 1920 when it peaked after the depression. If that is plausible, then one might be tempted to argue a case that a 35-year time lag fits these data reasonably well.

Figure 27. Heart disease mortality and income inequality



But how does this sit with our knowledge of the main individual-level risk factors – smoking, blood lipids and hypertension? There is little doubt that smoking is a strong risk factor for heart disease. Overlaying Figure 19, which displays smoking trends over the century, onto the heart disease trends suggests that the effect of smoking on heart disease is rather immediate, in that there seems little or no time lag between the rapid rise of smoking in the population and the equally steep increase in heart disease (Figure 28).

Figure 28. Heart disease mortality and cigarette consumption, 1900-98.



The same is not true for lung cancer, as shown in Figure 18, where there is a considerable time lag between the zenith of smoking in the population in the mid 1960s and the peak in lung cancer mortality that is currently emerging. At the risk of great over-simplification, there are three main processes implicated in heart disease – the development of atheroma, thrombo-embolic processes and arrythmia. Smoking most likely operates through the thrombo-embolic

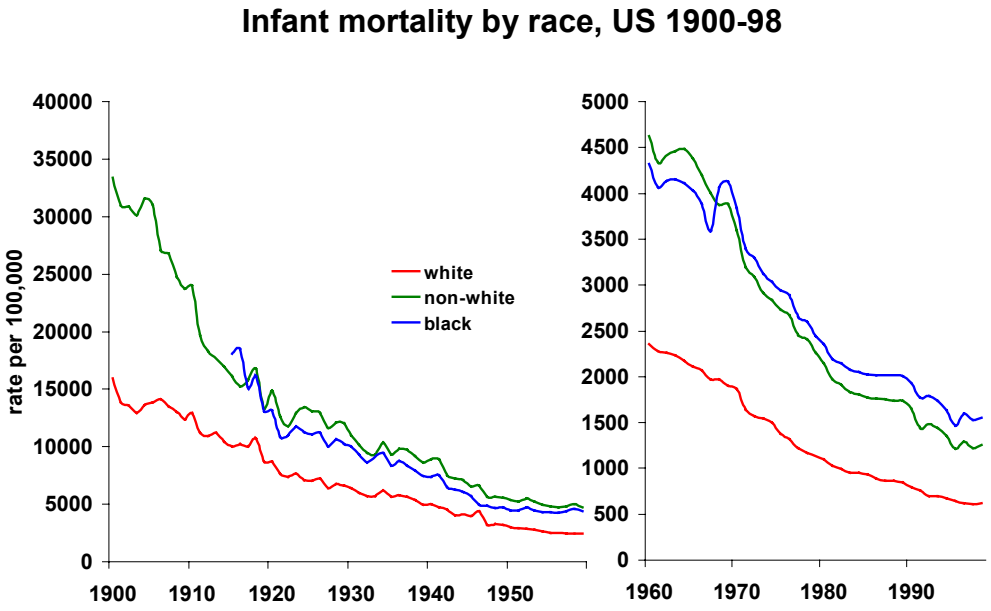
and/or arrhythmic pathways, thus plausibly being able to almost simultaneously affect heart disease given underlying susceptibility through the development of vulnerable atherosclerotic plaque – itself associated with blood lipids and hemostatic function. If income inequality worked through behavioral risk factors like smoking, and given that smoking maps almost directly onto the heart disease trends, the data here suggests that there would have to also be a 30-35 year time lag between exposure to income inequality and its effect on smoking. We are currently exploring long-term trend data on other major heart disease risk factors.

Thus, it may be possible that long-term trends in income inequality play some role in the rise and fall of heart disease, but it seems unlikely that it could plausibly work through the major established risk factors like smoking. Proponents of the income inequality hypothesis have suggested two pathways for income inequality to affect health – behavior and stress. We have already shown that trends in income inequality do not map easily onto trends in smoking. That leaves the stress pathway to be explored but it is difficult to see how this could be tested using historical trend data. To the extent that suicide may be an extreme marker for social stress, it is interesting to note that trends in suicide mortality shown in Figure 22 do not match the rise in income inequality over the same time period, but then this also needs to be examined over much longer time spans.

One final piece of evidence - some studies of income inequality have shown strong effects on infant and child health, perhaps because the time lags between exposure and outcome are likely to be relatively short. So is there any evidence that the long-term trends in income inequality affect infant mortality trends? Figure 29 shows 100-year trends in infant mortality from 1900-1960 in Panel and 1960-1998 in panel B – this was done to overcome the distorting effect of such high rates up until the 1920s. There is no clear link between 100-year trends in

income inequality and the continuous decline in infant mortality in all race groups over the same time period, so even for a cuase of death that may be plausibly linked to proposed income inequality mechanisms and that does not involve long time lags, there appears to be little association between long-term trends in infant mortality and income inequality.

Figure 29. Infant mortality, US, 1900-1998



Conclusion

So what can we say about links between income inequality and regional mortality?

- Figure 13 clearly shows that in the cross-section, income inequality is associated with all-cause mortality in each region of the US, but that it is the weakest in the South.

- 30-year trends in different causes of mortality show reasonable stability over time, whether the secular trend is increasing, decreasing or flat.

- There is considerable heterogeneity in the relative positions of regions in regard to different causes of mortality.

- Given the long term trends in income inequality, there appears no direct way that trends in regional income inequality could explain both the initial levels of these regional mortality differences or their trends between 1968 and 1998. Any such explanation would be further complicated by different time lags for different outcomes.

- At the national level, 20th century trends in heart disease appear more compatible with what is known about trends in the established risk factors for heart disease than with trends in income inequality or with how income inequality trends could be linked with trends in the major risk factors.

- At the national level, 20th century trends in infant mortality do not coincide with income inequality trends.

The evidence that income inequality affects population and individual health in the US seems robust in the cross-section but it appears difficult to reconcile either 30-year regional differences in causes-specific mortality with regional patterns and trends in inequality, or with 100-year national trends in heart disease or infant mortality. While this does not preclude a role for income inequality in affecting health, the evidence presented here suggests that such effects certainly cannot be reduced to simple processes that operate in all contexts over time.

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