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Epidemiology of heart disease: The influence of socioeconomic position☆

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The linkage between socioeconomic conditions and health is well documented [1]. A review article published in 1996 [2] describes considerable documentation by the US Public Health Service of linkages between low income and poor health between 1916 and the start of World War II. These efforts led to public calls for policy change to correct health inequity, but these calls faded as anti-Communist political voices tied public health with socialism and as the post-war economic boom leveled the economic structure of American society. Over the past 40 years, economic conditions in the United States have resulted in a growing wealth difference between the top and bottom Americans, and in the past decade clear trends in declining population health have emerged that likely result from these changes in economic conditions. It remains to be seen whether policy changes to mitigate declines in population health will be put forward, or whether political voices will again turn us away from trying to influence public health through economic policy. This review will describe population-wide trends in health outcomes, in particular cardiovascular outcomes, that might plausibly be linked with changes in economic conditions, provide credibility for linking changes in health outcomes with economic conditions by describing historical precedents and emerging insights into mechanisms, and suggest ways that cardiovascular practitioners may use this understanding in practice.

Recent trends

In 2015, Case and Deaton [3] published an analysis of data from the Centers for Disease Control and the American Community Surveys that showed a steady rise in mortality between 1998 and 2013 in a demographic subgroup of the U.S. population, non-Hispanic whites aged 45–54. Within that population of non-Hispanic whites, mortality increased among those with a high school degree or less but decreased among those with a college degree. The report was remarkable not only because it showed something other than the consistent decline in age specific mortality that had characterized the U.S. for more than a century, but also because it showed a rise in mortality in a demographic group that had hitherto demonstrated consistently better health than other groups. Because of the size of this demographic subgroup relative to the size of the population, the rising mortality trend in non-Hispanic white Americans was associated, in 2015, with a decrement in life expectancy at birth for the US as a whole compared with the year before, from 78.9 years in 2014 to 78.8 years in 2015 [4]. The age-adjusted death rate increased from 724.6 to 733.1 per 100,000, with the change largely coming from an increase in mid-life deaths; neither infant mortality or mortality in those older than 65 years changed significantly.

While cause-specific increases in mortality for white Americans during this time frame are most striking for suicide, overdose, and alcohol-related liver disease [4], the contribution to the increase from cardiovascular deaths has been significant. Meara and Skinner [5] have pointed out that the rise in so-called external deaths (suicide, overdose, and alcohol-related liver disease) was not large enough by itself to explain the rise in overall mortality for mid-life white Americans. The well-known downward trend in US cardiovascular mortality that began in the 1970s has not continued in recent years; the annual rate of decline in cardiovascular deaths was 3.79% from 2000–2011 but was only 0.65% from 2011–2014 [6]. Between 2014 and 2015 there was a statistically significant *increase* in deaths from cardiovascular disease, from 167.0 to 168.5 per 100,000 [4]. The arrested decline in cardiovascular mortality has been more significant in US whites than in African Americans or Hispanics. In an extension of their 2015 paper, Case and Deaton [7] report estimates of the annual average rate of change in heart disease mortality of −1.0% for non-Hispanic whites but of −2.7% for non-Hispanic blacks and −2.5% for Hispanics between 1999 and 2015. These differences, in association with the rise in external deaths, are responsible for the striking findings of Case and Deaton.

In the medical literature, speculation regarding the cause for this reversal has centered on the rapid rise in obesity with its concomitant rise in prevalence of diabetes and hypertension [8]. Trends in obesity, however, cannot wholly explain the arrested decline in cardiovascular mortality as described. Obesity has risen at least as much in African Americans and Hispanics as in whites. While obesity rates in Britain have paralleled those in the US over time, the 1999–2015 average annual rate of change in heart disease mortality for the UK was - 4.0% [7], significantly better than rates for the US described above in all racial/ethnic groups. An al-

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ternative explanation is that changes in socioeconomic conditions underlie declines in US population-wide health.

Socioeconomic trends and US mortality

Socioeconomic position has been conventionally defined by a measure of income, for example percentage of the federally-defined poverty level for families or individuals. Income as a single measure, however, serves incompletely as a descriptor of the level of individual well-being that results from one's position in a social and economic hierarchy. Socioeconomic position is better viewed as a complex construct incorporating a number of factors [9]. The economists Joseph Stiglitz and Amartya Sen [10] have advocated for including an individual's material conditions (determined by both income and wealth), educational attainment, participation in valued activities such as work, political voice, social connections, environmental conditions, and freedom from physical insecurity. Health is also a marker of socioeconomic position, and poor health can be both a cause and a consequence of diminished socioeconomic position. The adverse trends in population health, and in particular cardiovascular health, have been related to two socioeconomic factors, educational attainment and income.

A relationship between greater educational attainment and better health is well known [1], particularly for the US. Trends in the educational gradient in health support the view that changes in the relationship between socioeconomic conditions and health underlie declines in US population health.

Meara and colleagues [11] used census and death certificate data to compare life expectancy at age 25 for those with a high school education or less to those with more. In 1990, life expectancy was 0.4 years greater for those with greater educational attainment; in 2000 that gap had grown to 1.0 years. The authors estimate that differences in cancer mortality rates were responsible for the greatest growth in the gap at 18.7%, but heart disease and stroke were close behind, contributing 17.4%. Using the same data sources, Olshansky et al. [12] reported on a wider education difference, between those with less than a high school education and those with a college education or more, and a wider time gap, between 1990 and 2008. Differences were more striking. For white males in 1990, the difference in life expectancy at age 25 between the higher and lower education levels was 5.1 years; in 2008 the difference was 13.2 years. The change for white women was from 1.9 to 10.5 years, for black men 6.3 to 10.1, and for black women 2.0 to 6.6. Cause-specific data were not included. Case and Deaton [7] used a slightly more sensitive indicator than life expectancy, age-specific mortality, to investigate changes in the educational gradient in health in the US. They report that for men aged 50–54 without a college degree, mortality *increased* between 1998 and 2015 from 7.62% to 8.67% while for those with at least a college degree mortality *decreased* from 3.49% to 2.43%.

Income is an alternative way to investigate the changing relationship between socioeconomic factors and health. Fig. 1 shows changes over time in the distribution of income in the US represented as the percentage of all income that goes to the top 1% of earners. It provides a graphical summary of the changes in economic conditions that have driven changes in social structure. After a long period of stability beginning in the early 1940s when less than 10% of income went to the top 1%, that percentage began to rise sharply in approximately 1980 and has been over 20% for much of the past 20 years. The causes for the shift in income distribution in the US are subject to ongoing debate. Most frequently cited are loss of manufacturing jobs requiring less education to countries with emerging economies, gain of service sector jobs such as in finance and health care requiring greater education, and increasing concentration of economic activity among a smaller number of dominant firms. The common factor, however, seems to be poorer economic prospects for working class Americans. The temporal association between worsening income inequality and worsening differences in life expectancy by income is not meant to demonstrate causality. Rather, it highlights the magnitude of shifts in the economic structure of our society.

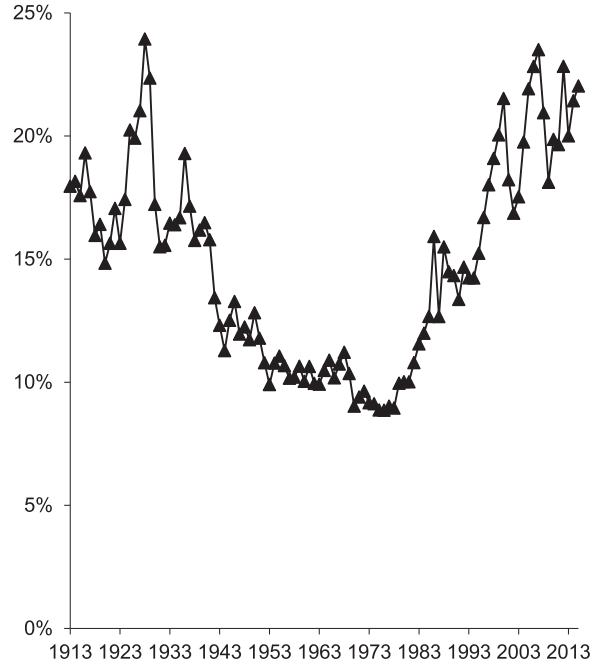

Fig. 1. Share of total income received by the top 1% of earners in the US. In 2015 the top 1% included those with incomes of greater than $443,000 per year. *Source*: Piketty and Saez, 2003 updated to 2015. https://eml.berkeley.edu/~saez/.

Chetty and colleagues [13] combined US Treasury tax records with Social Security death records for the years 1999–2014 and estimated life expectancy at birth as a function of income for individuals at a mean age of 53.0 years. As expected, they found that those with higher income had greater life expectancy. Averaged over the entire period, men in the top 1% of the income distribution had a projected life expectancy 14.6 years higher than those in the bottom 1%. For women the difference was 10.1 years. Comparing change in life expectancy across the income distribution, they show significant gains for those with the highest incomes and almost no change for those with the lowest. For women in the top 5% of the income distribution, estimated life expectancy increased 2.91 years between 2001 and 2014. For women in the bottom 5% of the income distribution, the increase over the same period was 0.04 years. For men, comparable changes were +2.34 years and +0.32 years.

Case and Deaton [7] give a more nuanced view of the association between income and mortality in recent years. While they show a negative correlation between income and mortality for middle-aged whites over the period from 1990 to 2015, the relationship does not hold within educational strata. This suggests income alone is not responsible for changes in health, and is consistent with the view that socioeconomic position is a complex construct incorporating a number of factors. Furthermore, they are not able to demonstrate a correlation between change in income and change in mortality for African Americans. They hypothesize that the effect of the changing economic landscape in the US on population health is the result of a dynamic interplay between

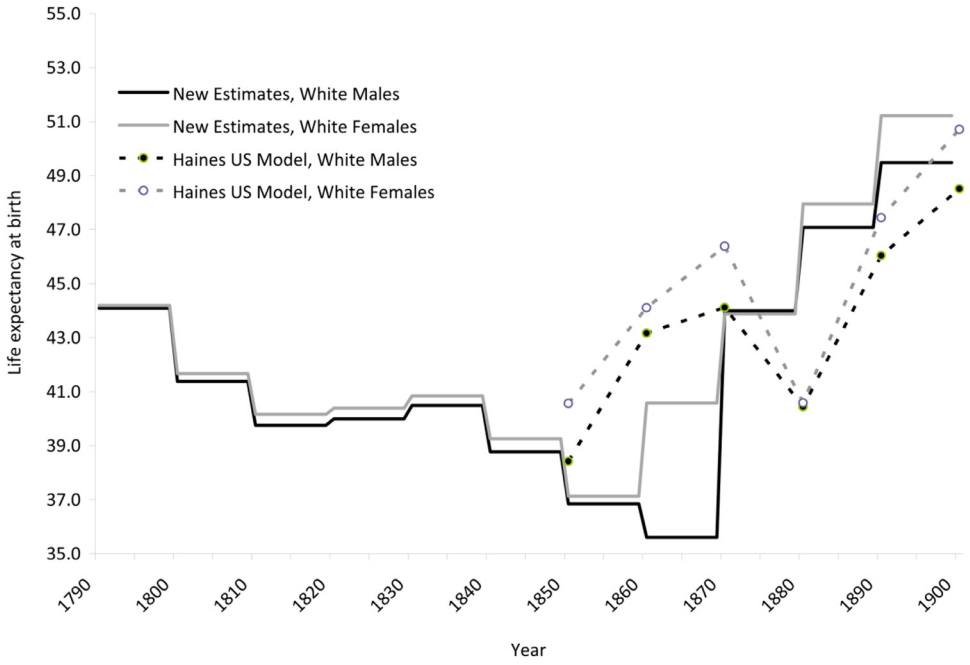

Fig. 2. Life expectancy at birth, white population of the United States, 1790–1900 (Hacker 2010).

economic conditions and social norms, with stagnant or declining real income for working class Americans leading to a "loss of structures that provide a meaning to life". They include among these structures marriage and social connectedness through such institutions as church, employment, and labor unions, and tentatively present data demonstrating greater effects on non-Hispanic whites. Loss of such structures leads to a rise in what they term "deaths of despair" – suicide and the consequences of drug and alcohol addiction. Possible relationships with the reversing trends in cardiovascular mortality are discussed below. They summarize their model as one of *cumulative disadvantage,* accruing over time beginning with entry into the labor force. The most troubling aspect of this theoretical model is that if true, improvement in population health is likely to require a generation.

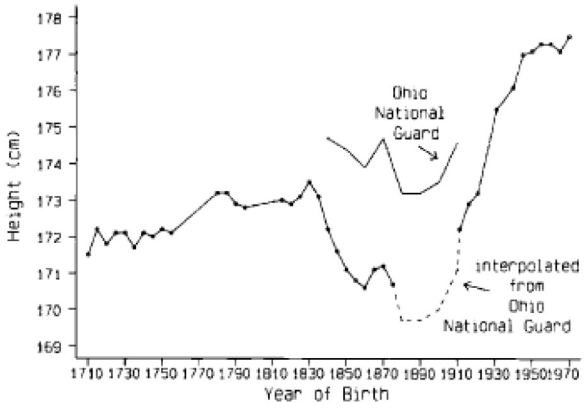

Fig. 3. Trends in heights of US males, 1710 −1970, taken from reference 15.

Historical precedents

Because long term declines in life expectancy have not occurred during our lifetimes, it has become easy to believe declines can't or won't persist over the long term. As will be shown in this section, history teaches us otherwise.

Fig. 2 [14] shows life expectancy at birth for whites in the United States from 1790 to 1900. Prior studies [15] have shown that life expectancy rose during most of the eighteenth century, yet life expectancy fell by nearly 10 years during the first half of the nineteenth century; this decline has been reported by others [16]. There is reason to believe the worsening of life expectancy during this time period may have its roots in socioeconomic conditions. Lindert and Williamson [17] have estimated income and income distribution for the United States from 1774 - 1860. According to these estimates, per capita income fell by 0.85% per year from 1774–1800 as a result of economic disruption caused by the American Revolution. While per capita income rose at an annual rate of 1.9% from 1800–1840 and 2.1% from 1840–1860, those gains were uneven. The top 1% of earners received 7.1% of all income in 1774, but 10% in 1860. Regional differences in income distribution were also present. In the South, the top 1% received 7.9% of income in 1774, but 12.7% in 1860. This regional variation was the result of economic growth in the South being substantially lower than the rest of the United States throughout the period, with the impact of lower growth born primarily by those of lower income. Evidence that income inequality in the early nineteenth century had an effect on population health comes from military records [18]. Average height of males from the eighteenth century through 1970 is shown in Fig. 3 [18]; lower adult height has been linked to both poor early nutrition and to lowered life expectancy [19–21] across countries and across time periods. The figure shows a general decline in height from about 1790 until nearly the end of the nineteenth century.

As with the contemporary situation, the link between income distribution and population health is likely to be complex. Easterlin [22] has argued persuasively that rapid urbanization in the 19th century, without accompanying improvements in sanitation, is the most likely proximate cause for stagnation in the improvement in life expectancy during that period. In this formulation, economic conditions are indirectly responsible for large scale changes in pop-

ulation health. Nonetheless, these historical data are a cautionary tale; declines in population health resulting from changing social and economic conditions can last decades.

Emerging insights into mechanism

In addition to historical precedent, mechanistic evidence lends plausibility to the existence of a link between socioeconomic change and change in cardiovascular mortality, but remains circumstantial. Research that directly links the hypothesized roots of contemporary socioeconomic change – job loss and wage stagnation among less educated American – to increased cardiovascular mortality is generally lacking.

Access to care

Perhaps the most obvious link between socioeconomic decline and worsening population health in the US is through limited access to medical care. Whether or not access to medical care has affected cardiovascular mortality remains unclear however.

Given that health insurance in the US is largely tied to employment, it is not surprising that trends in access to health insurance parallel income trends. The estimate from the National Health Interview Survey for the rate of non-elderly Americans lacking health insurance in 1978 and in 1980 was 12.0% for both years. That rate rose in the early 1980s, and between 1990 and 2013, just prior to institution of the major provisions of the Affordable Care Act, the rate was stable in a range between 16.1% and 18.2% [23,24]. Evidence relating access to health insurance and mortality is difficult to interpret for many reasons, but suggests the uninsured are at higher risk for death. A recent summary of the evidence [25] examined a variety of studies, including randomized trials and observational data, and concluded it most likely that being insured reduced mortality with an odds ratio of approximately 0.84.

Given that the rates of being uninsured remained stable after approximately 1990 but trends in mortality did not begin to rise until nearly 2000 suggests that lack of access to acute cardiovascular care is not a major mediator. Prolonged lack of access to preventive care may be responsible, and other mediators are likely important.

Allostatic load

Another hypothesized link between difficult socioeconomic conditions and worsened health is that of chronic physiologic stress. Response to psychological stress is mainly through activation of the sympathetic nervous system and of the hypothalamic-pituitary axis. Repeated and sustained activation of these systems leads to a change in their set point for these systems upward, in a process known as allostasis; chronic activation of stress response has been termed “allostatic load” [26]. This process has been observed in individuals in lower socioeconomic position, and is associated with elevation of markers of systemic inflammation as well as abnormalities of glucose and lipid metabolism [27]. These markers, in turn, are well-described predictors of later cardiovascular disease. Links between the cumulative disadvantage hypothesis of Case and Deaton described above have yet to be made.

Loss of social support

Social support has been defined as information made available to individuals that helps them see themselves as being in a network of individuals with mutual beneficial obligations. There is a substantial literature linking social support with health, including cardiovascular health.

Kawachi et al. [28] reported an association between social support (categorized into one of four levels) and cardiovascular outcomes in a cohort of 32,624 men aged 40–75 at entry. They reported that socially isolated men had a relative risk for cardiovascular mortality of 1.90 compared with men with the highest level of social support. Risk for stroke and death from accident or suicide were also elevated.

Poor social support has been consistently associated with increased mortality in patients with coronary heart disease. For example, Williams et al. [29] reported that unmarried individuals with angiographically proven coronary disease and without a close confidant had a hazard ratio for mortality of 3.34 compared with those reporting better social support. Berkman et al. [30] found that in a group of elderly individuals after myocardial infarction, those reporting a lack of emotional support had an odds ratio for 6-month mortality of 2.9.

The social disruption accompanying the economic changes under discussion here suggests lack of social support may be a component of the linkage with worsened population health.

Neighborhoods and cardiovascular disease

Another way of looking at the impact of social connections on health has been to look at clustering of cardiovascular disease in low socioeconomic neighborhoods.

Diez Roux et al. [31] used data from the Atherosclerosis Risk in Communities study to examine the relationship between neighborhood (defined by census block) socioeconomic disadvantage and coronary heart disease. Living in a neighborhood with a higher composite measure of disadvantage was associated with a higher risk of incident coronary heart disease, independent of individual socioeconomic position and Framingham risk. Strong additional evidence for the association between neighborhood of residence and risk for cardiovascular disease is provided in an analysis of data from the Moving to Opportunity Study [32]. In this study, 4,498 women living in poor neighborhoods were randomized to one of three groups: given a voucher and counseling that allowed a move to a low-poverty ($<$10% poverty) neighborhood, given a voucher to move to any neighborhood, or given no voucher (control group). After 10 years of follow-up, women receiving assistance to move to low-poverty neighborhoods were less likely to have a BMI $>$ 35 or a hemoglobin A1C $>$ 6.5% compared to women in the control group. It should be noted that other results of the MTO study have been mixed, although Chetty and colleagues [33] have reported that children who were below the age of 13 at the time of the move had incomes in their mid-twenties that was 31% higher than children from families in the control group.

Summary and conclusions

In the US in 2015, life expectancy decreased and cardiovascular mortality increased compared with prior years, in opposition to longstanding trends. These unexpected changes came after a longer trend of rising overall mortality and flattened decline in cardiovascular mortality in white Americans that began in approximately 2000. I have argued that the most plausible explanation for these trends lies in adverse social conditions that are the result of large changes in the structure of the US economy over the past 30–40 years. There is a significant body of literature linking increases in cardiovascular disease with exposure to adverse social conditions such as having poor access to medical care, experiencing breakdown in social support, living in poor neighborhoods, and

being exposed to chronic stress. There is historical precedent for declines in population health lasting a generation or more due to adverse social conditions that are the result of broad changes in the structure of the economy. If the social impact of adverse economic conditions is incurred early in life as many believe, we may be living with stagnant trends in cardiovascular health for many years.

How should we respond? The current focus on the opioid epidemic is entirely appropriate and necessary, but should not drown out the need for attention to a quieter epidemic of worsening cardiovascular population health. Cardiologists have taken responsibility for driving adoption of cardiovascular prevention practices since at least the 1970s. That tradition of leadership suggests cardiologists should advocate for improving public health through policy measures that address the problem of socioeconomic drivers of heart disease. Which policy changes will make a difference is not entirely clear and is deserving of attention. As noted above, those with health insurance have a lower mortality rate [24], so policy positions favoring reductions in the ranks of the uninsured likely will improve population health. Another example of policies that could mitigate the impact of socioeconomic position on health relate to early childhood education. An analysis of the impact in adulthood of two early childhood programs [34] suggests, particularly for males, that early intervention reduces likelihood of having hypertension and of smoking for example. Because educational attainment is strongly associated with cardiovascular health [35–37], educational policy to maximize the numbers of individuals finishing high school or enrolling in community or vocational colleges might be of value. Other potential policy targets are emerging. A recent paper [38] demonstrated an association between state level minimum wages and cardiovascular mortality, with a $1 increase in the state-level minimum wage above the federal minimum wage associated with a 3.5% decrease in state-level heart disease death rate for working age adults but only 1.1% decrease for those over the age of 65. If further research supports this association, adding public health arguments to the public debate over minimum wage changes will be useful. Because there is geographic variation in the impact of socioeconomic conditions on cardiovascular health, state- or locally-targeted interventions might be particularly effective. Chetty et al. [12] showed variation in life expectancy for those in the lowest income quartile across small areas in the United States of about 5 years for men and 4 years for women, concluding "low-income individuals tend to live longest … in affluent cities with highly educated populations and high levels of government expenditures…". Finally, in everyday practice we should strive to understand the social and economic conditions our patients struggle with, and modify our approach to care in response to that understanding.

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