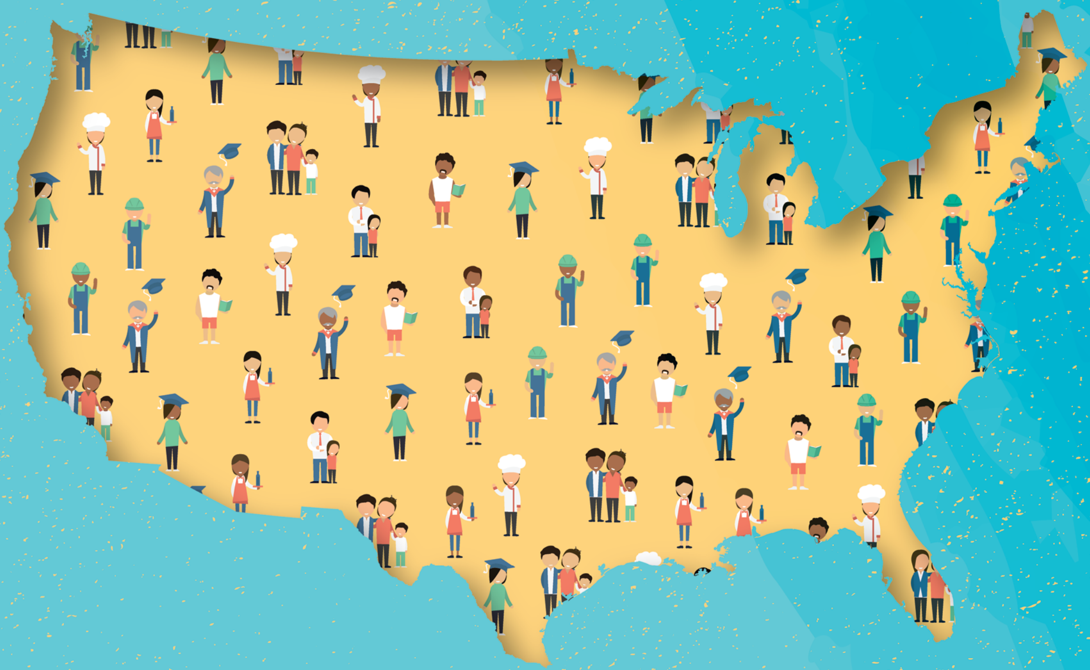
EXPLAINING THE US HEALTH DISADVANTAGE



THE ROLE OF SOCIAL INEQUALITIES

KAREN VAN HEDEL

Explaining the US Health Disadvantage:
The role of social inequalities

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Explaining the US Health Disadvantage:
The role of social inequalities

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De rol van sociale ongelijkheid

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CONTENTS

Introduction

Chapter 1

General introduction

US HEALTH FROM AN INTERNATIONAL PERSPECTIVE

Understanding trends in health and mortality from an international perspective is important. First, it informs us whether a certain health pattern is observed in multiple countries, or whether it is confined to a specific country, and therefore caused by factors specific to that country. Second, international comparisons of health allow us to draw lessons on how one country is doing in comparison to other (similar) countries, and possible reasons for why it does better or worse. For example, health and changes in health over time may be different in the United States (US) than in Europe as a result of differences in the health care system or different social policies. In turn, similar health patterns for the US and Europe may indicate a more universal link between an exposure and a health outcome.

Whereas in 1980 US life expectancy was comparable to that of Western Europeans, life expectancy grew at a slower rate in the US than in Western European countries, resulting in a lower US life expectancy in recent years (Table 1);[1–3] in 2015, US life expectancy at birth was 2 to 4 years lower than life expectancy at birth in most Western European countries.[1] Mortality from five of the six leading causes of death decreased for men and women in the US between 1969 and 2013; rates declined for heart disease, cancer, stroke, unintentional injuries, diabetes mellitus, but not for chronic obstructive pulmonary disease.[4] On a population level, this resulted in declining all-cause mortality rates. However, mortality did not decline for all subgroups of the US population; among white non-Hispanic men and women of all educational levels, mortality in midlife (ages 45 to 54 years) increased between 1999 and 2013.[5,6] Even though the total health expenditure has been higher in the US than in any of the other industrialized countries since the 1980s,[7] the US is not necessarily doing better than those countries in terms of health.

TABLE 1 – **Life expectancy at birth (in years) in the United States and selected Western European countries**

	Men			Women		
	1980	2015	Δ	1980	2015	Δ
United States	70.0	76.4	6.4	77.4	81.2	3.8
France	70.1	79.5	9.4	78.2	86.0	7.8
Germany	69.5	78.7	9.2	76.0	83.6	7.6
Italy	70.7	81.1	10.4	77.4	86.0	8.6
Spain	72.3	80.6	8.3	78.5	86.3	7.8
Sweden	72.8	80.6	7.6	78.9	84.6	5.7

Notes. Δ: life expectancy in years in 2015 – life expectancy in years in 1980. Data came from the World Bank.[1]

Recently, it has been shown that life expectancy has been stalling or even declining for the US population. This adverse trend has been attributed to deteriorating health among certain subgroups, e.g., low educated Americans, for whom living conditions have worsened over time.[6,8] Until recently, this declining life expectancy was only observed for the US. However, new evidence indicates that a similar trend may be happening in the United Kingdom in more recent years,[9] indicating that declining life expectancy could also be taking place in other high-income countries. Therefore, the declining US life expectancy may only be a first sign of future fluctuations in life expectancy in other industrialized countries.

THE US HEALTH DISADVANTAGE

Besides lower life expectancy, Americans are also worse off in terms of many specific causes of death, self-reported health measures, behavioral risk factors, and biomarkers as compared to individuals from other industrialized countries.[10–13] I will refer to this phenomenon as 'the US health disadvantage', which has been the focus of several studies over the last decades. For example, a study by Ho[14] found that men and women in the US had higher mortality below age 50 than men and women in 16 other high-income countries. She found that this mortality difference below age 50 accounted for two-thirds of the US disadvantage in terms of life expectancy for men, and two-fifths of the disadvantage for women. Banks and colleagues[13] found a health disadvantage in terms of self-reported illnesses and biological markers of diseases for US adults aged 55 to 64 when compared to English adults of the same ages. Similarly, Avendano and colleagues[15] found that US adults aged 50 to 74 years were worse off in terms of prevalence of chronic diseases as compared to English and European adults, irrespective of their wealth level. However, those in the lowest income groups were most disadvantaged.[15] The US health disadvantage is reported to be larger for women than for men and present across the entire life course.[10,13,16–19] This is in line with findings from a study by Martinson and colleagues,[12] which reported that the health disadvantage of Americans relative to the English already starts at early ages and continues into old age.

EXPLANATIONS FOR THE US HEALTH DISADVANTAGE

Despite extensive research in the last two decades, it has not been possible to fully explain the US health disadvantage. The National Research Council has issued several reports[17–19] on the US disadvantage in life expectancy and mortality of Americans aged 50 and older, and across the life-course by also including children and younger adults.[18] In these reports, several possible explanations have been put forward, among which the public health and medical care system, individual health related behaviors, factors related to the physical and social environment, and socioeconomic factors.[17–20] This section discusses the evidence for these common explanations.

Health care system

As compared to health systems in many high-income countries, the US health system is less equitable, it relies more often on out-of-pocket expenses, and it has been historically less successful in achieving universal health coverage.[19,21,22] However, research suggests that for cancer and cardiovascular disease, two main causes of death, health care in the US is not inferior to that of other OECD countries in terms of avoiding deaths.[18] For example, cancer screening is generally more extensive in the US than in Europe and survival rates after a stroke or heart attack are generally more favorable in the US than in other high-income countries.[17] Hence, there is no consistent evidence that the US health care system performs worse than those of other countries and is thus unlikely to account for the US health disadvantage. Even though the quality of care in the US is not necessarily poorer, due to larger inequalities in access to care in the US than in Europe, not everyone in the population may benefit equally from high quality care in the US. This lack of access to good quality health care in the US undoubtedly influences overall health and mortality. These problems with the American health care system are important and should not be overlooked as potential factors contributing to the US health disadvantage, although some research suggests it may only partially provide an explanation for the US health disadvantage.[19]

Health behaviors

Modifiable behavioral risk factors, and in particular smoking, poor diet, physical inactivity, and alcohol consumption, have been previously identified as leading causes of mortality in the US.[23] Consequently, these health behaviors may play a role in (partly) explaining the US health disadvantage. As smoking is a major cause of mortality and historical smoking patterns differ per country, it could provide an explanation for health differences between countries.[18] Smoking prevalence started to increase earlier and reached a higher peak in the US than in Western European countries, even if smoking prevalence in the US is currently lower than that in many other high-income countries.[19,24] As a result of the earlier rise and higher peak of smoking prevalence in the US, smoking has played an important role in why the health of Americans was falling behind.[19] Smoking explains some of the US mortality disadvantage at older ages, as a result of the high prevalence of smoking among men and women decades ago and the observed lag between smoking behavior and smoking-related mortality.[19] However, it would explain little of the US health disadvantage at younger ages, due to the declining prevalence of smoking. Additionally, as smoking affects diseases and mortality related to smoking only and does not allow for an explanation of other health outcomes, it is one of many factors affecting trends in life expectancy.[18]

Beside smoking, obesity may also play a role in explaining (some of) the US health disadvantage. Although obesity in itself is not a health behavior, it is strongly influenced by unhealthy behaviors, such as poor diet and lack of regular physical activity. Obesity has been linked to several negative health outcomes, such as diabetes and heart disease. In the last few decades, the obesity rate has been higher in the US than in other high-income countries for both men and women.[19] Overall, obesity has reduced life expectancy in many high-income countries, but more so in the US than in other high income countries.[25] Results from a recent study by Preston and colleagues[26] indicated that rising body mass index between 1988 and 2011 in the US slowed its mortality improvement and reduced life expectancy at age 40 by almost a year in 2011. In the next few decades, obesity rates are expected to increase even more for all countries and the US is expected to also have one of the highest obesity rates in the future.[27] Although obesity plays a role in explaining part of the US disadvantage in life expectancy, it is not exactly clear how obesity will impact mortality improvements in the US and other industrialized countries for the years to come.[18,19]

Alcohol use is another individual health behavior that has been associated with a higher risk of multiple adverse health outcomes, such as liver cancer and other cancer types.[28,29] In recent years, alcohol consumption measured as liters per capita has decreased in most OECD countries,[30] and alcohol consumption is lower in the US than in most Western European countries. Although Americans generally drink less than Europeans, there are more traffic accidents due to alcohol in the US than in Europe.[19] However, there is no evidence that substance abuse such as alcohol and drug use influences the US health disadvantage mainly due to lack of empirical data.[19]

Although the relationship between behavioral factors and the US health disadvantage has been studied comprehensively, international differences in behavioral risk factors, i.e. smoking, alcohol consumption, physical activity, and body mass index, were found to account for only part of the US health disadvantage in terms of chronic diseases and physical limitations.[15] Consequently, other factors besides individual health behaviors should be examined.

Social determinants of health

Social determinants of health have also been put forward as a main explanation for understanding health differentials.[31,32] Social determinants of health have been defined by the World Health Organization as "the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life".[33]

An important social determinant of health is socioeconomic position, which refers to the social and economic factors that influence what positions individuals or groups hold within the structure of a society.[34,35] Education, occupation, income, and wealth are the most frequently used indicators of socioeconomic position. These cannot be used interchangeably as they are not identical and do not capture the same dimension of socioeconomic position.[36] However, regardless of which (single) indicator of socioeconomic position is used, a social gradient in health is found in many studies;[37–47] individuals who are better-off in terms of education, occupational class, income or wealth enjoy better health and live longer than those worse-off.

Education

Using education as an indicator of socioeconomic status has several advantages; e.g., it is comparatively easy to measure, it has a high response rate, it is fairly stable beyond young adulthood, and it is relevant regardless of age or working circumstances.[34] Educational inequalities in health have been reported for men and women at all ages in most, if not all, industrialized countries. Compared to individuals with low education, individuals with higher education have lower mortality rates, (report) better health and well-being, and undertake healthier behaviors.[48–51] For example, the higher educated are less likely to smoke, to be obese, or to be heavy drinkers, and they are more likely to be physically active or to use preventive health care.[51,52]

Education may contribute to differences in health between the US and Europe in two different ways. First, differential distributions of education in the two regions may result in health differences between the US and Europe. The level of education is on average higher in the US than in Europe. In 2015, 45 percent of Americans had tertiary education, 45 percent had upper secondary education, and the remaining 10 percent had less than upper secondary education. By contrast, the percentages for men and women in the European Union were 32, 47 and 21, respectively.[53,54] How this higher average educational level and the seemingly more favorable educational distribution in the US may contribute to the US health disadvantage remains to be examined. Second, differential effects of education on health may (also) result in health differences between the two regions; e.g., being low educated may be more detrimental for one's health in the US than in Europe. Relative educational inequalities in health have persisted, or even widened, over time in most Western countries.[55–59] Nevertheless, they have been reported to be even larger in the US than in other industrialized countries. The exact contribution of these larger educational inequalities in health in the US to the US health disadvantage has not been identified yet.

Demographic and sociodemographic factors

Demographic and sociodemographic factors may also play a significant role in influencing health besides socioeconomic factors. Demographic factors, such as gender, age, race, and ethnicity are strongly associated with health. For example, women live longer than men, even though they report more chronic diseases than men, and ill-health and mortality risks increase with age.[60,61] Differences in the degree of residential and racial segregation between the US and other industrialized countries may also offer part of the explanation of the US health disadvantage, as the US is characterized by relatively higher levels of racial and residential segregation compared to other industrialized countries.[62–64] Residential segregation by socioeconomic factors is also larger in the US than in several European countries, and may thus also play a role in (partly) explaining the US health disadvantage, and should not be overlooked in future research.

Sociodemographic factors, such as marital status, household composition, and parenthood, also contribute substantially to the health of individuals; for example, marriage and cohabitation positively influence health, whereas divorce and singlehood have a negative effect on health. Therefore these factors should not be disregarded as potential contributors to the US health disadvantage.

Marital status

In general, married individuals enjoy better physical and mental health than individuals who are not married.[65–72] Marriage may also positively affect health behaviors, as a partner may encourage healthy behaviors (e.g., healthy dietary habits) and discourage unhealthy ones (e.g., smoking).[73] This health differential also applies to mortality, as mortality rates were smaller among married individuals than unmarried individuals.[74–77]

Over the recent decades, marriage rates have declined, and divorce rates have increased or remained constant, resulting in decreasing crude marriage rates in most, if not all, industrialized countries.[78] However, both marriage and divorce rates were higher in the US than in Europe in 2014,[78] although this may obscure the higher levels of cohabitation in many European countries.[79] Divorce has been shown to be associated with worse health outcomes.[80] As the prevalence of marriage and/or divorce, and the association of these with health may differ between the US and Europe, the factors may in turn impact the US health disadvantage. However, the contribution of marital status distributions to the US health disadvantage has not been examined yet.

Parenthood

Parenthood may have beneficial and/or detrimental effects on an individual's health.[81–84] For example, the social integration that follows parenthood may positively influence an individual's mental health, but its strains (e.g., in terms of housework or spousal disagreement) may negatively influence health.[85] As a result, the relationship between parenthood and health is complex and empirical evidence has led to seemingly inconsistent conclusions. Several studies have found that parents report better health than non-parents,[86–89] whereas other studies found worse health among parents,[90–94] or no difference at all by parenthood status.[94–96]

In the last few decades, fertility rates declined in all industrialized countries;[97] in 2015, the total fertility rate in the US was 1.89 and in Europe it was (on average) 1.60.[98] These lower fertility rates have led to less individuals becoming parents, but also to smaller family sizes for those with children.[99] Country differences in family policy, i.e. the generosity of social policies related to parenthood such as maternity leave and child support, may influence health. For example, the more generous family policies in Europe such as paid maternity leave, and better and affordable child care and support may partly counteract the negative health effects of stress related to having children. As these social benefits are less generous in the US than in Europe, they may contribute to (some of) the US health disadvantage.

Combining marriage, parenthood, and employment

In 2011, the most frequent household type across OECD countries was that of a couple, which covered, on average, half of the populations. Approximately half of these couples also lived with children, although the percentages differ across countries.[100] For example, 20% of the US households consisted of couples living with children, whereas on average this was the case for 25% of the European households.[100] Over the last few decades, female labor force participation increased considerably; e.g., it increased from 43.3% in 1970 to 58.6% in 2010 for American women and from 40.8% in 1983 to 50.5% in 2010 for European women.[101] Partly due to this development, 42.6% of the US households consisting of couples with children had two full-time employed partners in 2011.[102] In the vast majority of the remaining couples living with children, one partner was working full-time but the other partner was either working part-time (13.1%) or not employed (35.3%). These distributions also vary considerably across countries. For example, of the German households consisting of couples with children, in 22.4% of them both partners were full-time employed, in 43.6% one of the partners was working part-time, and in 27.1% of the households one of the partners was not employed.

Most studies on the health effects of combining marriage, parenthood, and employment have focused on women, because women have been more likely to feel the competing demands of combining work and family life than men. However, research on the health impacts of performing these multiple roles has yielded mixed results. Several studies have found that having multiple roles is associated with better self-reported health, less longstanding illnesses, lower morbidity and mortality, and greater well-being.[103–107] This is in line with the 'role accumulation hypothesis', which states that combining multiple roles is good for a woman's health as taking on the role as an employee may bring a woman income and possibly financial independence, as well as a social network outside that of her family.[108] However, other studies found that having multiple roles negatively affected women's health,[92,109] which is in line with the 'multiple role hypothesis'. This hypothesis states that combining multiple roles negatively affects a woman's health as a result of the increased levels of stress that accompany having to fulfill multiple roles.[110,111] In a third set of studies, no supportive results were found for either of the two hypotheses; having multiple roles was neither beneficial nor detrimental for a woman's health.[112–116]

Changes in the rates of marriage, fertility, and labor force participation have been reported for both American and European women. However, fertility rates remained higher for American than European women,[117] and labor force participation increased more for American than for European women.[118] This resulted in more American women facing the prospect of combining work and family roles. As a result of the less generous social policy context in the US than in Europe, American women with multiple roles may be worse off in terms of their health than European women. For example, American mothers and families lack access to (generous) support policies, such as paid maternity leave, when compared to European mothers and families. Hence, differences in the prevalence and health effect of combining multiple roles, as well as country specific social policy climates, may play a role in explaining (some of) the US health disadvantage.

Single parenthood, a special case of combining multiple roles

A specific case of combining multiple roles is single parenthood, i.e. raising children without the support of a partner. As a result of less individuals being currently married, single parenthood has become more prevalent in the US and Europe over the last few decades.[119] For example, in the US 19.5% of the families with children in 1980 was a single parent family. This percentage grew to 26.5% in 2001.[119] Whereas in Denmark, the percentage of single parent families increased from 13.4% to 18.4% for the same period.[119] Most research has focused on single mothers, as single parent families are predominantly headed by a woman.[119] Lone motherhood has been linked to higher mortality rates, worse health, and less healthy behaviors.[120–126] Single parents have the responsibility to care for their children as well as being the main breadwinner of the family, while they lack support from a partner; single parents are thus particularly disadvantaged. As more families are headed by single parents in the US than in Europe,[119] and social (family) policies are less generous in the US, differences in the occurrence and health effects of single parenthood may contribute to the explanation of (some) of the US health disadvantage. For example, American (working) lone mothers may experience a more stressful life than their European counterparts due to the lack of (in)formal support policies such as paid maternity leave in the US.[127]

Social policies

Even though previous research has studied the US health disadvantage and its possible explanations, none of the suggested explanations seem to fully explain the US health disadvantage. Many of these explanations relate to factors that could be influenced by the social and policy context. For example, differences in public policy focusing on education or social protection may contribute to differences in health between the US and other high-income countries.[20] Public policy focusing on education, e.g., policies improving access to higher education, may modify the educational distribution within a country and affect health. But social protection policies, such as minimum wage policies, unemployment insurance policies, and childcare policies may also influence (some of) these social factors. These policies may decrease the (health) disadvantage of employed and unemployed individuals, but also of single parents. For example, policies providing paid maternity leave or better child care and support may especially aid men and women combining multiple roles as they would allow them to find better reconciliation between their work and family lives. Differences in the social and policy context of countries may thus also play a crucial role in explaining (some of) the US health disadvantage.[12,16,20,128]

RESEARCH QUESTIONS

The aim of this thesis is to gain insight in the role of social inequality – focusing on education, work, and family factors in mid-life – in explaining the difference in health between the US and Europe, the so-called US health disadvantage. Overall, there has been considerable attention given to medical care and public health systems as well as behavioral factors as potential explanations for the US health disadvantage.[19,20] However, research has been less concerned with the possible contribution of social determinants such as education, work, and family. This is remarkable as health inequalities by these social factors have been well established for both men and women in all industrialized countries. Furthermore, previous studies have focused on either young[129] or older adults,[13,15] while exposures during mid-life have received less attention. This thesis addresses these gaps in the current research literature by examining inequalities by social factors, measured primarily in mid-life, as potential contributors to the US health disadvantage.

This PhD thesis focuses on the following two research questions:

1. What is the contribution of inequalities in health by educational level to differences in health and mortality between the United States and European countries?

2. What is the contribution of work and family factors to differences in health and mortality between the United States and European countries?

Outline of this thesis

The first part of this thesis (Chapters 2 and 3) addresses the first research question. Chapter 2 investigates to what extent larger educational inequalities in the US than in 7 European countries (Belgium, Denmark, Finland, France, Norway, Sweden and Switzerland) explain the higher mortality observed in the US. Chapter 3 examines and compares changes in educational inequalities in mortality over time in the US and 7 European countries (Belgium, Denmark, Finland, Italy, Slovenia, Sweden, Switzerland).

The second part (Chapters 4 to 6) addresses the second research question. Chapter 4 examines whether work and family factors, alongside material and behavioral factors, play a role in explaining relative educational inequalities in mortality. Additionally, this chapter examines whether explanations for these educational inequalities differed for men and women. In Chapter 5, I examine the interaction between marriage and labor force participation on mortality in the US and 6 European countries (Austria, England and Wales, Finland, Hungary, Norway, and the Basque country, Spain). Chapter 6 presents a study on the link between work-family life histories and cardiovascular disease risk in older age in the US and European countries. This thesis ends with a conclusion and general discussion of research findings in Chapter 7.

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Part one

Educational inequalities in health and the US health disadvantage

Chapter 2

The contribution of national disparities to international differences in mortality between the United States and 7 European countries

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ABSTRACT

Objectives. This study examined to what extent the higher mortality in the United States compared to many European countries is explained by larger social disparities within the United States. We estimated the expected US mortality if educational disparities in the United States were similar to those in 7 European countries.

Methods. Poisson models were used to quantify the association between education and mortality for men and women aged 30 to 74 years in the United States, Belgium, Denmark, Finland, France, Norway, Sweden, and Switzerland for the period 1989 to 2003. US data came from the National Health Interview Survey linked to the National Death Index and the European data came from censuses linked to national mortality registries.

Results. If people in the United States had the same distribution of education as their European counterparts, the US mortality disadvantage would be larger. However, if educational disparities in mortality within the United States equaled those within Europe, mortality differences between the United States and Europe would be reduced by 20% to 100%.

Conclusions. Larger educational disparities in mortality in the United States than in Europe partly explain why US adults have higher mortality than their European counterparts. Policies to reduce mortality among the lower educated will be necessary to bridge the mortality gap between the United States and European countries.

INTRODUCTION

The United States has lower life expectancy at birth than most Western European countries. In 2009, life expectancy in the United States was 76 years for men and 81 years for women, between 2 and 4 years less than in several European countries.[1] The disadvantage is greater for women than for men and originated in the 1980s.[2] The US health disadvantage is found not only for life expectancy, but also for self-reported health measures,[3,4] biomarkers,[3] and many specific causes of death[5,6] across the entire life course.[3–5,7]

A recent report by the National Research Council suggests that smoking and obesity explain an important part of the US mortality disadvantage.[2,8,9] However, an approach that solely emphasizes behavioral differences is impoverished by ignoring the role of socioeconomic and environmental determinants.[10] A substantial body of research suggests that most behavioral risk factors are socially patterned; lower education or income are associated with a higher prevalence of smoking, excessive alcohol consumption, obesity, and poor dietary patterns.[11–19] In addition, European countries and the United States differ in many aspects of the physical and social environment that can affect population health and that are in turn socially patterned within each country. For example, the socioeconomic distribution of access to healthy food differs between countries.[20] Social environmental factors related to safety, violence, social connections, social participation, social cohesion, social capital, and collective efficacy have also been shown to influence health and in turn differ between countries and socioeconomic groups.[21] Indeed, differences in mortality between the United States and Europe are larger among those with a lower educational level,[6] suggesting that larger educational disparities in mortality, which partly coincide with differences in behavior, partly explain why Americans have higher mortality than Europeans.

The United States is characterized by relatively higher levels of income inequalities,[22] residential and racial segregation,[23–25] and financial barriers to health care access[2,26] than any European country. Social protection policies and benefits are also less comprehensive in the United States than in Europe, including policies on early education and childcare programs,[27] access to high-quality education,[28] employment protection and support programs,[29,30] and housing[29,31] and income transfer programs.[31,32] A plausible hypothesis is that the more unequal distribution of resources and less comprehensive policies contribute to the more unfavorable risk factor profile and poorer health of lower-educated Americans as compared with corresponding Europeans.[4,33,34] A follow-up report by the National Research Council and the Institute of Medicine published in 2013 concluded that there is a lack of evidence on how these factors explain the US health disadvantage.[21] The aim of this article is to assess to what extent larger educational disparities in mortality explain why Americans have higher mortality than Europeans.

METHODS

Data from 5 waves (1989–1993) of the US National Health Interview Survey (NHIS) were used.[35] The NHIS is a survey of the noninstitutionalized population of the United States, with a 10-year mortality follow-up through linkage with the National Death Index. Our study focuses on ages 30 to 74 years. We excluded the population aged 75 years and older because previous evidence suggests that US mortality at these ages is similar or lower than that in other high-income countries.[36,37] In addition, NHIS might underestimate mortality at older ages as a result of excluding the institutionalized population from their sample. Though rates of institutionalization are only around 1% at ages younger than 75 years, they are around 11% at older ages.[38] Analyses by the National Center for Health Statistics have shown that NHIS survival rates closely resemble those of the general US population younger than 75 years.[39] US data comprised 290,231 individuals aged 30 to 74 years at baseline and 28,935 deaths in the 10 years of mortality follow-up.

The European data came from the Eurothine project, in which census data from the early 1990s were linked to national mortality registries with a follow-up until the early 2000s for Belgium, Denmark, Finland, France, Norway, Sweden, and Switzerland.[40] Data comprised entire national populations except data for France (which were based on a 1% representative sample of the French population excluding residents of overseas territories, members of the military, and students) and Switzerland (which excluded non-Swiss nationals). Table A (available in the supplemental materials) shows details of the sample and follow-up in each country. Although most countries had a mortality follow-up of around 10 years, follow-up for Belgium and Denmark was 5 years. To account for differences in age at death because of these different lengths of follow-up, we included individuals aged 30 to 79 years at baseline for Belgium and Denmark, but ages 30 to 74 years for all other countries. Data included more than 20 million individuals and 1.6 million deaths.

We focused on mortality patterns by educational level, a key indicator of socioeconomic status. Data on mortality by education were available for all countries included, but data on mortality by occupational class or income were not available in most countries. Educational attainment was measured by years of completed schooling in the United States and by the highest level of educational attainment in Europe. Data were harmonized so that educational levels in both the United States and the European countries approximately correspond with levels as defined in the International Standard Classification of Education[41] (ISCED). Based on this classification, education was reclassified into 3 levels: lower secondary or less education (≤11 years of schooling in the United States, ISCED levels 0 to 2), upper secondary education (12–15 years of schooling in the United States, ISCED levels 3 and 4), and tertiary or higher education (≥16 years of schooling in the United States, ISCED levels 5 and 6). Distributions of education in our data matched those in data from the International

Institute for Applied Systems Analysis/Vienna Institute of Demography provided by the World Bank (Table B, available in the supplemental materials).

We consider all-cause mortality as well as mortality from cancer, cardiovascular disease, other diseases, and external causes. Table C (available in the supplemental materials) provides the *International Classification of Disease, 10^th^ Revision* codes for each cause of death.

Mortality rates for each country were estimated by Poisson regression models and were directly standardized to the US 1995 intercensal population. Then absolute and relative differences in mortality between the United States and each European country were calculated from these age-standardized rates. Additionally, country-specific rate ratios indicating the age-adjusted risk of mortality associated with lower educational attainment were obtained.

Thereafter, we combined the estimates from the Poisson model with the observed distribution of educational level in each country to obtain the expected US mortality under 3 scenarios. In the first scenario, we estimated what the US mortality rate would be if the United States had the same educational distribution as each European country. The second scenario estimated what the US mortality would be if the mortality risk associated with lower educational attainment in the United States would be the same as in each European country. In the third scenario, we estimated what the US mortality would be if the United States had both the distribution of education and mortality risk associated with lower educational attainment as each European country.

Because the US mortality disadvantage is greater among women than among men,[2] this article only presents results for women. The results for men can be found in the supplemental materials (Tables D–F and Figure A).

RESULTS

US women had higher levels of educational attainment than women in most European countries (Table 1). The percentage of women with lower secondary education or less ranged from 20% in the United States to 36% in Norway and 40% to 67% in all other European countries. The percentage of women with tertiary or more education ranged from 7% in Switzerland to 20% in Finland, whereas the United States ranked second highest with 19% (together with Denmark and Sweden).

Table 1 shows that US women had higher total mortality than women in all European countries except Denmark. Mortality differences for the total population, however, concealed large variations by educational level. Among women with lower secondary or less education, mortality rates were higher in the United States than in any European country except Denmark, which had similar rates as the United States. By contrast, higher educated women in the United States had similar rates of mortality as higher educated women in several European countries. Correspondingly, rate ratios of mortality by educational level were larger in the United States than in most European countries (low educated women: rate ratio [RR]=1.93, 95% confidence interval [CI]: 1.80, 2.08; and mid educated women: RR=1.45, 95% CI: 1.35, 1.55). International differences in educational distribution, mortality rates, and mortality rate ratios were also present among men; they followed the same pattern, but differences in mortality were smaller and less consistent (Table D).

Educational disparities and US-Europe mortality differences

The first columns in Table 2 show the observed mortality rates and differences in mortality between the United States and each European country. US women had between 40 (Belgium) and 316 (France) more deaths per 100,000 person-years than their European counterparts. Subsequent columns show the estimated US mortality rate and differences between the United States and each European country under 3 scenarios. If the United States had the same educational distribution as the European countries (scenario 1), the US mortality disadvantage would be even larger than observed. For example, if US women would have the same educational distribution as French women, the United States would have 457 more deaths per 100,000 person-years than their French counterparts. This finding reflects the fact that US women had higher levels of educational attainment than women in most European countries (Table 1). A similar result was found for men (Tables D and E).

If the United States had the same relative risk of mortality associated with lower educational attainment as European countries (scenario 2), the US mortality disadvantage would be smaller than observed (Table 2). For example, if US women would have the same risk associated with lower educational attainment as women in Switzerland, the difference in mortality between the United States and Switzerland would be 48 deaths per 100,000 person-years, a much smaller difference than the observed 217 deaths per 100,000 person-years. The mortality advantage of the United States over Danish women would increase substantially if the United States had the same educational disparities in mortality as Denmark.

The more favorable educational distribution of the US population only partly compensates for the larger inequalities in mortality: if the United States had the educational distribution and the educational inequalities in mortality of European countries (scenario 3), the US mortality disadvantage would be smaller, except in the comparison with Sweden (Table 2). For example, the difference in mortality among American and Swiss women would be 94 instead of 217 deaths per 100,000 person-years in this scenario.

The results for scenario 2 suggest that larger educational disparities in mortality within the United States explained more than 100% of the mortality disadvantage with Belgian and Finnish women. They explained 78% ([217-48]/217) of the US mortality disadvantage with Swiss women, and 58%, 45%, and 20% of that with Norwegian, French, and Swedish women, respectively. For men, similar results were found (Table E).

TABLE 1 – **Educational distribution, mortality rates, and mortality rate ratios for women by country: United States and 7 European countries, 1989–2003**

Education level[a]	United States	Belgium	Denmark	Finland	France	Norway	Sweden	Switzerland
Percentage								
Low	20	67	53	51	62	36	41	40
Mid	61	19	28	29	28	47	40	53
High	19	14	19	20	10	17	19	7
Mortality rate per 100,000 person-years[b] (95% CI)								
Low	1023 (988, 1059)	801 (796, 806)	1037 (1029, 1046)	794 (788, 799)	530 (515, 544)	801 (794, 808)	657 (653, 661)	657 (652, 662)
Mid	766 (745, 786)	628 (615, 641)	814 (800, 829)	631 (621, 641)	387 (362, 412)	616 (609, 624)	534 (529, 539)	523 (518, 528)
High	529 (495, 564)	582 (567, 597)	664 (646, 683)	528 (516, 539)	334 (293, 375)	484 (471, 497)	402 (395, 410)	472 (457, 487)
Total	806 (789, 823)	766 (761, 770)	960 (953, 966)	733 (728, 737)	490 (478, 502)	695 (690, 700)	587 (584, 590)	589 (586, 593)
Rate ratio (95% CI)								
Low	1.93 (1.80, 2.08)	1.38 (1.34, 1.41)	1.56 (1.52, 1.61)	1.50 (1.47, 1.54)	1.58 (1.40, 1.80)	1.66 (1.61, 1.70)	1.63 (1.60, 1.67)	1.39 (1.35, 1.44)
Mid	1.45 (1.35, 1.55)	1.08 (1.04, 1.11)	1.23 (1.19, 1.27)	1.20 (1.17, 1.23)	1.16 (1.01, 1.33)	1.27 (1.24, 1.31)	1.33 (1.30, 1.36)	1.11 (1.07, 1.15)
High (Ref)	1	1	1	1	1	1	1	1

Notes. CI: confidence interval; Ref: reference category. [a] Low represents lower secondary or less education, mid represents upper secondary education, high represents tertiary or more education. [b] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years).

TABLE 2 – **Mortality disadvantage for US women: United States and 7 European countries, 1989–2003**

	Observed		Scenario 1: Expected with European educational distribution[c]		Scenario 2: Expected with European relative risks of mortality by education[d]		Scenario 3: Expected with European educational distribution[c] and European relative risks of mortality by education[d]	
Countries	Mortality rate[a] (95% CI)	US mortality disadvantage[b] (95% CI)	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]
United States	806 (789, 823)							
Belgium	766 (761, 770)	40 (23, 58)	940 (928, 952)	174 (162, 187)	618 (610, 626)	−148 (−157, −139)	705 (696, 714)	−61 (−71, −51)
Denmark	960 (953, 966)	−154 (−171, −136)	890 (879, 901)	−70 (−83, −57)	710 (701, 719)	−250 (−262, −239)	780 (770, 790)	−180 (−192, −168)
Finland	733 (728, 737)	73 (56, 91)	914 (902, 926)	181 (169, 194)	666 (657, 675)	−67 (−77, −57)	738 (729, 748)	5 (−5, 15)
France[e]	490 (478, 502)	316 (299, 333)	947 (935, 959)	457 (440, 473)	665 (656, 674)	175 (160, 189)	781 (771, 791)	291 (176, 306)
Norway	695 (690, 700)	111 (93, 128)	866 (855, 877)	171 (159, 183)	742 (733, 751)	47 (37, 58)	796 (786, 806)	101 (90, 112)
Sweden	587 (584, 590)	219 (202, 236)	879 (868, 891)	291 (281, 304)	762 (752, 772)	175 (165, 185)	818 (808, 829)	231 (220, 242)
Switzerland	589 (586, 593)	217 (199, 234)	884 (873, 895)	295 (283, 307)	637 (629, 645)	48 (39, 57)	683 (674, 692)	94 (85, 103)

Notes. CI: confidence interval. [a] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years). [b] The observed or expected US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [c] The impact of differences in educational distribution was assessed by estimating the US mortality disadvantage if the educational distribution in the United States was replaced by that in each Western European country. [d] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage if the educational disparities in mortality in the United States were replaced by those in each Western European country. [e] For each country except France, the all-cause mortality rate is the sum of the cause-specific mortality rates. Because cause-specific mortality data were not available for the French population, the all-cause mortality rate was included in this table. [f] The CIs calculated for the expected US mortality rates and disadvantages were based on a Monte Carlo simulation assuming a normal distribution with 10,000 samples.

TABLE 3 – **Mortality disadvantage for US women by cause of death (scenario 2): United States and 7 European countries, 1989–2003**

	All-cause mortality		Cancer mortality		Mortality from cardiovascular disease		Mortality from other diseases		Mortality from external causes	
Countries	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)
Belgium	40 (23, 58)	−148 (−157, −139)	27 (18, 37)	−16 (−37, 4)	9 (0, 17)	−60 (−86, −34)	19 (11, 28)	−47 (−69, −26)	−15 (−17, −12)	−25 (−29, −20)
Denmark	−154 (−171, −136)	−250 (−262, −239)	−79 (−88, −70)	−104 (−126, −81)	8 (−1, 17)	−21 (−52, 11)	−67 (−75, −58)	−101 (−127, −75)	−16 (−18, −13)	−25 (−29, −20)
Finland	73 (56, 91)	−67 (−77, −57)	55 (45, 64)	13 (−8, 33)	−23 (−32, −14)	−65 (−94, −35)	64 (55, 72)	12 (−12, 35)	−22 (−25, −19)	−26 (−32, −21)
France[c]	316 (299, 333)	175 (160, 189)	NA	NA	NA	NA	NA	NA	NA	NA
Norway	111 (93, 128)	47 (37, 58)	14 (4, 23)	−10 (−33, 12)	33 (24, 42)	25 (−8, 59)	64 (56, 73)	41 (14, 68)	0 (−3, 2)	−9 (−14, −4)
Sweden	219 (202, 236)	175 (165, 185)	44 (34, 53)	27 (4, 50)	73 (64, 81)	68 (34, 102)	106 (97, 114)	89 (60, 117)	−3 (−5, 0)	−9 (−14, −3)
Switzerland	217 (199, 234)	48 (39, 57)	48 (39, 58)	10 (−11, 31)	93 (84, 101)	44 (15, 72)	81 (73, 90)	9 (−12, 30)	−5 (−8, −2)	−15 (−19, −10)

Notes. CI: confidence interval; NA: not available. [a] The US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [b] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage (expected) in a scenario in which the educational disparities in mortality in the US were replaced by those in each Western European country. [c] Cause-specific mortality data were not available for the French population.

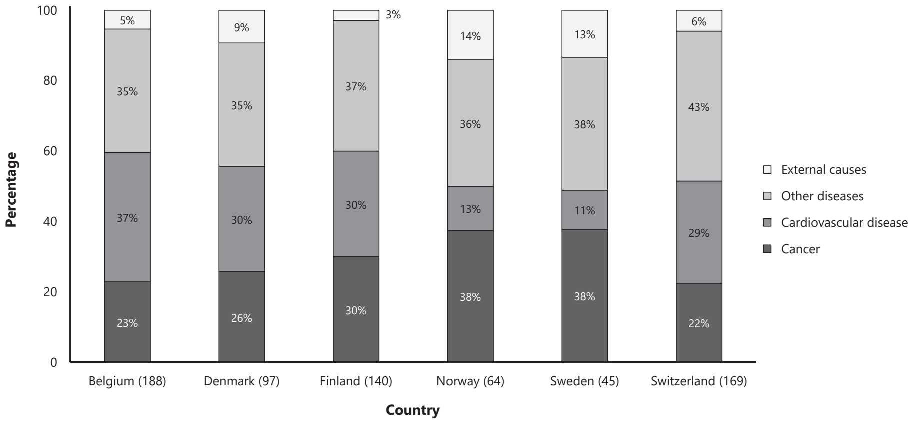

FIGURE 1 – **Contribution of specific causes of death to the change in US mortality (dis)advantage for women: United States and 7 European countries, 1989–2003.**
Note. Numbers in parentheses indicate the absolute change in all-cause mortality.

Cause-specific results

The difference in mortality between the United States and each European country is disaggregated by broad causes of death in Table 3. For each cause of death, the first column shows the observed difference, which indicates that US women had a mortality disadvantage compared with most European countries for cancer, cardiovascular disease, and other diseases, but not for external causes. The next column shows the estimated difference if the United States had the same educational disparities in cause-specific mortality as the corresponding European country (scenario 2). Under this scenario, all cause-specific US mortality disadvantages would be reduced or even reversed, indicating that the mortality disadvantage is partly or wholly explained by larger educational disparities in mortality in the United States. For example, comparing the United States and Belgium, the US mortality disadvantage for cancer would be reversed from 27 to –16, for cardiovascular disease from 9 to –60, and for other diseases from 19 to –47. For external causes the US mortality advantage would increase from –15 to –25 per 100,000 person-years (negative values indicate higher mortality in Europe than in the United States).

Figure 1 shows the contribution of causes of death to the change in US all-cause mortality disadvantage that would occur if the United States would have the same relative risks of cause-specific mortality associated with lower educational attainment as the European countries. As we have seen, and again taking cancer and Belgium as an example, this scenario would reverse the observed US disadvantage from 27 into an advantage of 16. In Figure 1, this change of 43 is expressed as a percentage of the change in US all-cause mortality disadvantage. Because the latter was 188 deaths per 100,000 person-years (a disadvantage of 40 would become an advantage of 148; Table 2), cancer accounted for 23% (43/188) of the change in all-cause mortality. Cardiovascular disease in the case of Belgium, cancer in the case of Norway and Sweden, and other diseases in the case of Finland and Switzerland made the largest contributions. In the case of Denmark, where this scenario increased the US all-cause mortality advantage, other diseases made the largest contribution as well. Corresponding results for men can be found in Table F and Figure A.

DISCUSSION

US women had higher mortality than women in all European countries included except Denmark. If American women had the same distribution of education as Europeans, differences in total mortality between the United States and Europe would be even larger, reflecting the fact that Americans had higher levels of educational attainment than Europeans. By contrast, if educational disparities in mortality within the United States were similar to those within European countries, mortality differences between the United States and European countries would be reduced by between 20% and 100%. This reflects the fact that the United States had larger educational disparities in mortality than European countries. A similar pattern was found for men. Although US men did not have the highest mortality, if educational disparities in mortality within the United States were similar to those within European countries, US mortality estimates would decrease. Larger educational disparities in mortality from cancer, cardiovascular disease, and other diseases all contributed substantially to the US mortality disadvantage.

Limitations

Cross-national differences in methods of data collection, baseline periods, follow-up periods, and population covered might have affected our mortality estimates. A key concern is that data for the United States excluded the institutionalized population (e.g., people living in nursing homes), while data for the European countries generally included the total population. Because institutionalized populations are less healthy than those living in the community, our estimates are likely to underestimate mortality differences between the United States and European countries. In sensitivity analyses, we tested the impact of this by restricting participants to ages 30 to 64 years, among whom institutionalization rates are relatively low. Results on the relative contribution of disparities to total mortality differences between countries were largely unchanged (results available upon request). Thus, although NHIS underestimates mortality for the United States by excluding the institutionalized population,[39] this does not seem to bias estimates on the contribution of national disparities to cross-national mortality differences.

US men and women had higher levels of education than their European counterparts, which is supported by other sources, such as data from the Organisation for Economic Cooperation and Development.[42,43] In this study education in the United States was measured based on years of schooling, while in Europe it was based on ISCED highest educational attainment levels. Furthermore, educational systems, practices, curricula, and other aspects of education differ among countries.[43,44] We therefore cannot exclude that part of the variation in educational disparities in mortality observed in our study is spurious, but differences between the United States and European countries (Table 1) appear too large to be only a result of differences in educational classification or educational systems.

A recent study by Ho[45] and a related National Research Council report[21] show that mortality from external causes among those younger than 50 years is higher in the United States than in European countries, except for Finnish men. In our data, mortality from external causes was in general lower in the United States than in Europe. This is partly attributed to the fact that our data cover a different and older age range than that covered by Ho.[45] In addition, part of the difference might be attributed to the exclusion of the institutionalized population in the US NHIS (e.g., incarcerated individuals). We may therefore have somewhat underestimated the role of mortality from external causes in explaining US-Europe differences in all-cause mortality.

We did not consider race in our analyses because data for Europe did not include information on this variable. In the United States, large racial differences in mortality have been documented.[46–50] In sensitivity analyses, we calculated the US mortality disadvantage under the 3 scenarios for US whites and blacks separately (Tables G–L). These results show that our general conclusion holds for both racial groups: educational disparities in mortality contribute substantially to the US mortality disadvantage for both US blacks and whites.

Interpretation

Previous reports suggest that smoking, obesity, and other proximal risk factors partly explain the US health disadvantage.[2,8,9,21,51] Our results do not necessarily contradict those findings, because larger educational inequalities in mortality might also be attributed to larger inequalities in smoking, obesity, and similar downstream risk factors.[2] Nevertheless, our results suggest that larger educational inequalities in mortality in the United States make a much more important contribution to the US mortality disadvantage than was previously known. While it is true that the US mortality disadvantage applies to all educational groups (Table 1), disparities are larger among those with lower educational attainment. This suggests that the exceptionally high mortality among least educated Americans to an important extent drives the US mortality disadvantage.

Possible explanations for larger educational inequalities in mortality in the United States than in Europe include larger inequalities in material circumstances (e.g., income), psychosocial stress, health behaviors (e.g., smoking), and access to high-quality medical care. Not only are income inequalities as such larger in the United States,[52–54] but income differences between educational groups are also larger in the United States than in many European countries. The rate of return to schooling, that is the percentage change in wages because of an additional year of schooling, is larger in the United States than in Western Europe.[55]

Lower educational attainment is associated with higher levels of psychosocial stress,[56,57] but whether this association is stronger in the United States than in Europe is unknown. One possible source of psychosocial stress could be work-family strain, that is the combination of job demand, job control, and social support, both from formal and informal sources. From 1950 onwards, female labor force participation has increased dramatically in both the United States and Western Europe, but this increase was largest for US women.[58] Marriage rates differ across countries,[59] as well as the level of formal and informal support available for working parents.[60–62] High labor force participation, high fertility, low marriage rates, and the relative lack of proximity to extended family in the United States might partly contribute to the poorer health of US women as compared with their counterparts in European countries such as Sweden and Norway, where family support policies and systems are well established and widely available to women from all socioeconomic groups.

Health behaviors vary across educational groups[63–65] and these variations might be larger in the United States than in Western Europe. Comparative studies are lacking, but in view of the fact that the smoking epidemic started earlier and reached a higher peak in the United States particularly among women, larger inequalities in smoking in the United States offer a potential explanation for larger educational disparities in mortality in the United States.[12,63,66] In addition, obesity prevalence is higher, and educational disparities in obesity might be larger in the United States than in Europe.[33,34]A recent report reviewed evidence of differences in medical care and public health systems and concluded that medical care is not systematically of worse quality in the United States than in European countries.[21,67,68] In addition, US survival rates for several chronic conditions contributing to the US health disadvantage, such as heart disease, ischemic stroke, and cancer, are better in the United States than in other high-income countries, suggesting that on average care for these conditions might not be worse in the United States than in European countries.[21,67,69,70] However, inequalities in health care utilization might well be larger in the United States than in Europe,[57,71] which might then still contribute to larger inequalities in mortality in the United States.[70,72] A larger proportion of the lower educated lack health insurance in the United States than in European countries, where health insurance coverage is more universal. Nevertheless, most of the differences in health between socioeconomic groups are likely because of factors outside the influence of medical care (e.g., poor health behaviors and material circumstances).[73]

Consistent with findings from previous studies, differences in mortality rates between the United States and several European countries were smaller and less consistent for men than for women.[74] This finding has been attributed to gender differences in smoking patterns across countries and their lag effect on mortality.[63,74] In the decades preceding our mortality observations smoking prevalence was similar in the United States and in several European countries among men, but higher in the United States than in most European countries among women. This might have contributed to a larger US mortality disadvantage among women. Other explanations have pointed to a possible role of weaker social protection policies to combine work and family responsibilities in the United States than in Europe, which if causally related to mortality, would affect women more than men.

Conclusions

To our knowledge, our study is the first to show that larger educational disparities in mortality in the United States make a substantial contribution to the gap in mortality between the United States and European countries. Despite similar or higher levels of educational attainment in the United States than in Europe in the cohorts examined, the mortality risk associated with lower educational attainment is larger in the United States than in most European countries, a pattern that contributes substantially to the US mortality disadvantage. These findings emphasize the potential benefit of policies to tackle health disparities in the United States. Although more evidence is required, the larger educational inequalities in mortality in the United States than in many European countries suggest that policies (within and outside the health sector) that address this inequality and the health of the most disadvantaged groups might contribute to improve overall population health in the United States.

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SUPPLEMENTAL MATERIALS

TABLE A – **Overview of US and European data sets on socioeconomic status and mortality, 1989–2003**

Country	Type of study	Baseline	Follow-up	Subjects, No.	Person-years, No.	Deaths, No.
United States	National, longitudinal, mortality study for a representative sample of the population (NHIS)	1989–1993	1999–2003	290,231	2,908,019	28,935
Belgium	National, longitudinal, census-linked mortality study	1991	1995	5,299,156	24,861,016	283,349
Denmark	National, longitudinal, census-linked mortality study	1996	2000	3,035,204	14,619,327	183,284
Finland	National, longitudinal, census-linked mortality study	1990	2000	2,714,179	25,874,201	270,130
France[a]	National, longitudinal, census-linked mortality study for a representative sample of 1 percent of the population	1990	1999	256,962	2,478,782	20,215
Norway	National, longitudinal, census-linked mortality study	1990	2000	2,108,523	19,956,768	213,022
Sweden	National, longitudinal, census-linked mortality study	1991	2000	4,482,137	43,042,216	393,038
Switzerland[b]	National, longitudinal, census-linked mortality study	1990	2000	2,906,552	27,910,587	255,270

Notes. [a] Residents of overseas territories, members of the military, and students were excluded. [b] Non-Swiss nationals were excluded.

TABLE B – **Comparison of the educational distributions in our data with the educational distributions in the IIASA/VID data provided by the World Bank for women**

	Educational distribution in our data			Educational distribution in IIASA/VID data		
Countries	Low and mid, %.	High, %.	Ranking based on the lowest percentage of low and mid educated	Low and mid, %.	High, %.	Ranking based on the lowest percentage of low and mid educated
United States	81	19	2/3/4	80	20	4
Belgium	86	14	6	83	17	6
Denmark	81	19	2/3/4	78	22	3
Finland	80	20	1	74	26	1
France	90	10	7	86	14	7
Norway	83	17	5	81	19	5
Sweden	81	19	2/3/4	77	23	2
Switzerland	93	7	8	90	10	8

Note. This table combines the low and middle educational categories into a single group to match the levels as summarized by the IIASA/VID data.

TABLE C – The International Classification of Disease codes for the causes of death distinguished in this chapter

	ICD-10 coding	
Cause of death	United States	Western Europe
Cancer	C00–D48	C00–D48
Cardiovascular disease[a]	I00–I99	I00–I99
Other diseases[b]	A00–B99, E10–E14, J10–J18, J40–J47, K25–K28, K35–K38, K40–K46, K70, K73–K74, K80–K82, N40, O00–O99, R00–R99	A00–B99, E10–E14, F10, G40–G41, J10–J18, J40–J47, K25–K28, K35–K38, K40–K46, K56, K70–K87, N40, O00–O99, R00–R99
External causes[c]	V01–Y98	V01–Y98

Notes. [a] US coding excludes I79 (disorders of arteries, arterioles and capillaries in diseases classified elsewhere). [b] US coding excludes A43 (nocardiosis), K71 (toxic liver disease), K72 (hepatic failure, not elsewhere classified), K75 (other inflammatory liver diseases), K76 (other diseases of liver), K77 (liver disorders in diseases classified elsewhere), and K83 (other diseases of biliary tract), K85 (acute pancreatitis), K86 (other diseases of pancreas) and K87 (disorders of gallbladder, biliary tract and pancreas in diseases classified elsewhere). [c] US coding excludes Y35 (legal intervention) and Y90–98 (supplementary factors related to causes of morbidity and mortality classified elsewhere).

TABLE D – **Educational distribution, mortality rates, and mortality rate ratios for men by country: United States and 7 European countries, 1989–2003**

Education level[a]	United States	Belgium	Denmark	Finland	France	Norway	Sweden	Switzerland
Percentage								
Low	20	61	43	49	50	30	40	20
Mid	54	22	38	30	37	48	43	56
High	26	17	19	22	13	22	16	24
Mortality rate per 100,000 person-years[b] (95% CI)								
Low	1698 (1653, 1743)	1590 (1581, 1599)	1659 (1646, 1672)	1700 (1690, 1710)	1285 (1259, 1312)	1498 (1486, 1510)	1151 (1144, 1157)	1477 (1465, 1490)
Mid	1251 (1220, 1282)	1265 (1247, 1282)	1400 (1382, 1417)	1410 (1393, 1427)	955 (920, 990)	1194 (1183, 1204)	953 (946, 959)	1123 (1115, 1131)
High	813 (775, 852)	1000 (982, 1017)	982 (960, 1003)	939 (925, 954)	622 (576, 668)	871 (857, 886)	705 (695, 714)	829 (818, 840)
Total	1282 (1259, 1306)	1481 (1473, 1488)	1508 (1498, 1517)	1528 (1521, 1536)	1132 (1113, 1152)	1272 (1265, 1279)	1026 (1022, 1030)	1165 (1159, 1171)
Rate ratio (95% CI)								
Low	2.09 (1.98, 2.21)	1.59 (1.56, 1.62)	1.69 (1.65, 1.73)	1.81 (1.78, 1.84)	2.06 (1.91, 2.23)	1.72 (1.68, 1.75)	1.63 (1.61, 1.65)	1.78 (1.75, 1.81)
Mid	1.54 (1.47, 1.61)	1.26 (1.24, 1.29)	1.43 (1.39, 1.46)	1.50 (1.47, 1.53)	1.53 (1.41, 1.66)	1.37 (1.34, 1.39)	1.35 (1.33, 1.37)	1.35 (1.33, 1.37)
High (Ref)	1	1	1	1	1	1	1	1

Notes. CI: confidence interval; Ref: reference category. [a] Low represents lower secondary or less education, mid represents upper secondary education, high represents tertiary or more education. [b] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years).

TABLE E – **Mortality disadvantage for US men: United States and 7 European countries, 1989–2003**

Countries	Observed		Scenario 1: Expected with European educational distribution[c]		Scenario 2: Expected with European relative risks of mortality by education[d]		Scenario 3: Expected with European educational distribution[c] and European relative risks of mortality by education[d]	
	Mortality rate[a] (95% CI)	US mortality disadvantage[b] (95% CI)	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]
United States	1282 (1259, 1306)							
Belgium	1481 (1473, 1488)	−198 (−222, −175)	1516 (1497, 1536)	35 (15, 56)	1057 (1044, 1071)	−424 (−436, −409)	1190 (1175, 1205)	−291 (−308, −275)
Denmark	1508 (1499, 1517)	−225 (−249, −202)	1394 (1376, 1411)	−114 (−134, −94)	1147 (1132, 1162)	−361 (−388, −344)	1210 (1195, 1226)	−298 (−316, −280)
Finland	1528 (1521, 1536)	−246 (−269, −223)	1481 (1462, 1500)	−47 (−67, −26)	1170 (1155, 1185)	−358 (−375, −341)	1290 (1274, 1306)	−238 (−256, −220)
France[e]	1132 (1113, 1152)	150 (126, 173)	1502 (1483, 1521)	370 (350, 390)	1273 (1257, 1289)	141 (124, 158)	1486 (1467, 1505)	354 (334, 374)
Norway	1272 (1265, 1279)	10 (−13, 33)	1363 (1346, 1380)	90 (72, 109)	1139 (1125, 1154)	−133 (−149, −117)	1194 (1179, 1209)	−78 (−94, −62)
Sweden	1026 (1022, 1030)	256 (233, 280)	1425 (1407, 1443)	399 (381, 418)	1115 (1101, 1129)	89 (75, 104)	1195 (1180, 1210)	169 (153, 185)
Switzerland	1165 (1159, 1171)	117 (94, 141)	1286 (1270, 1303)	121 (104, 139)	1143 (1128, 1158)	−22 (−38, −7)	1146 (1131, 1161)	−19 (−35, −3)

Notes. CI: confidence interval. [a] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years). [b] The observed or expected US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [c] The impact of differences in educational distribution was assessed by estimating the US mortality disadvantage if the educational distribution in the United States was replaced by that in each Western European country. [d] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage if the educational disparities in mortality in the United States were replaced by those in each Western European country. [e] For each country except France, the all-cause mortality rate is the sum of the cause-specific mortality rates. Because cause-specific mortality data were not available for the French population, the all-cause mortality rate was included in this table. [f] The CIs calculated for the expected US mortality rates and disadvantages were based on a Monte Carlo simulation assuming a normal distribution with 10,000 samples.

TABLE F – **Mortality disadvantage for US men by cause of death (scenario 2): United States and 7 European countries, 1989–2003**

	All-cause mortality		Cancer mortality		Mortality from cardiovascular disease		Mortality from other diseases		Mortality from external causes	
Countries	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)	Observed US mortality disadvantage[a] (95% CI)	Expected US mortality disadvantage[b] (95% CI)
Belgium	–198 (–222, –175)	–424 (–436, –409)	–100 (–112, –88)	–166 (–191, –141)	4 (–11, 18)	–91 (–119, –63)	–77 (–87, –67)	–127 (–152, –102)	–25 (–30, –21)	–40 (–50, –30)
Denmark	–225 (–249, –202)	–361 (–388, –344)	–67 (–80, –55)	–140 (–165, –115)	–24 (–38, 9)	–77 (–108, –46)	–116 (–126, –106)	–119 (–149, –89)	–18 (–23, –14)	–25 (–36, –14)
Finland	–246 (–269, –223)	–358 (–375, –341)	27 (15, 39)	–47 (–72, –22)	–194 (–208, –179)	–232 (–264, –200)	24 (14, 34)	18 (–12, 48)	–104 (–108, –99)	–98 (–111, –85)
France[c]	150 (126, 173)	141 (124, 158)	NA	NA	NA	NA	NA	NA	NA	NA
Norway	10 (–13, 33)	–133 (–149, –117)	16 (4, 28)	–71 (–94, –47)	–50 (–65, 36)	–83 (–116, –51)	48 (38, 58)	32 (4, 61)	–4 (–9, 0)	–11 (–22, –0)
Sweden	256 (233, 280)	89 (75, 104)	97 (84, 109)	5 (–18, 28)	36 (22, 50)	–17 (–48, 14)	130 (120, 141)	116 (87, 145)	–7 (–12, –2)	–16 (–26, –5)
Switzerland	117 (94, 141)	–22 (–38, –7)	1 (–11, 13)	–47 (–74, –20)	82 (67, 96)	17 (–13, 47)	56 (46, 67)	43 (14, 72)	–22 (–26, –17)	–35 (–45, –25)

Notes. CI: confidence interval; NA: not available. [a] The US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [b] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage (expected) in a scenario in which the educational disparities in mortality in the US were replaced by those in each Western European country. [c] Cause-specific mortality data were not available for the French population.

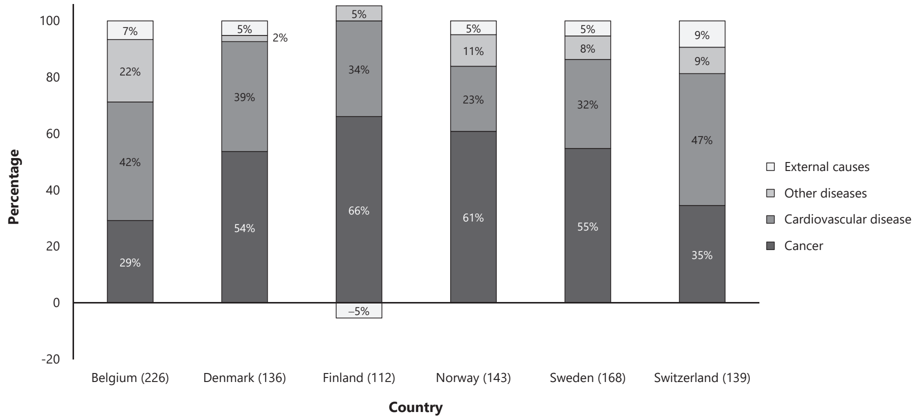

FIGURE A – Contribution of specific causes of death to the change in US mortality (dis)advantage for men: United States and 7 European countries, 1989–2003.
Note. Numbers in parentheses indicate the absolute change in all-cause mortality.

TABLE G – Educational distribution, mortality rates, and mortality rate ratios for women by race in the United States

Education level[a]	US, all	US, whites	US, blacks	US, others
Percentage				
Low	20	18	29	54
Mid	61	63	60	36
High	19	19	11	10
Mortality rate per 100,000 person-years[b] (95% CI)				
Low	1023 (988, 1059)	1014 (972, 1056)	1342 (1246, 1439)	720 (668, 772)
Mid	766 (745, 786)	749 (727, 770)	1034 (959, 1109)	607 (539, 675)
High	529 (495, 564)	530 (494, 566)	715 (561, 868)	368 (260, 476)
Total	806 (789, 823)	781 (763, 799)	1142 (1090, 1195)	636 (597, 675)
Rate ratio (95% CI)				
Low	1.93 (1.80, 2.08)	1.91 (1.76, 2.07)	1.88 (1.43, 2.32)	1.96 (1.38, 2.53)
Mid	1.45 (1.35, 1.55)	1.41 (1.31, 1.51)	1.45 (1.13, 1.76)	1.65 (1.13, 2.17)
High (Ref)	1	1	1	1

Notes. CI: confidence interval; Ref: reference category. [a] Low represents lower secondary or less education, mid represents upper secondary education, high represents tertiary or more education. [b] Rates have been directly standardized towards the US 1995 intercensal population (in deaths per 100,000 person-years).

TABLE H – Educational distribution, mortality rates, and mortality rate ratios for men by race in the United States

Education level[a]	US, all	US, whites	US, blacks	US, others
Percentage				
Low	20	18	31	56
Mid	54	57	58	32
High	26	25	11	12
Mortality rate per 100,000 person-years[b] (95% CI)				
Low	1698 (1653, 1743)	1685 (1632, 1739)	2168 (2027, 2310)	1190 (1096, 1284)
Mid	1251 (1220, 1282)	1235 (1201, 1268)	1559 (1427, 1692)	994 (896, 1092)
High	813 (775, 852)	813 (771, 854)	1082 (859, 1305)	659 (541, 776)
Total	1282 (1259, 1306)	1248 (1224, 1273)	1802 (1713, 1891)	1019 (951, 1086)
Rate ratio (95% CI)				
Low	2.09 (1.98, 2.21)	2.07 (1.94, 2.21)	2.00 (1.57, 2.44)	1.81 (1.46, 2.15)
Mid	1.54 (1.47, 1.61)	1.52 (1.44, 1.60)	1.44 (1.11, 1.78)	1.51 (1.22, 1.80)
High (Ref)	1	1	1	1

Notes. CI: confidence interval; Ref: reference category. [a] Low represents lower secondary or less education, mid represents upper secondary education, high represents tertiary or more education. [b] Rates have been directly standardized towards the US 1995 intercensal population (in deaths per 100,000 person-years).

TABLE I – Mortality disadvantage for US white women: United States and 7 European countries, 1989–2003

Countries	Observed		Scenario 1: Expected with European educational distribution[c]		Scenario 2: Expected with European relative risks of mortality by education[d]		Scenario 3: Expected with European educational distribution[c] and European relative risks of mortality by education[d]	
	Mortality rate[a] (95% CI)	US mortality disadvantage[b] (95% CI)	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]
United States	781 (763, 800)							
Belgium	766 (761, 770)	15 (–3, 34)	934 (900, 967)	168 (135, 201)	603 (562, 644)	–163 (–204, –122)	691 (644, 738)	–75 (–122, –28)
Denmark	960 (953, 966)	–179 (–197, –160)	882 (855, 909)	–78 (–105, –51)	675 (629, 721)	–285 (–331, –239)	744 (694, 795)	–216 (–266, –165)
Finland	733 (728, 737)	48 (30, 67)	906 (876, 937)	174 (144, 204)	658 (613, 703)	–75 (–119, –30)	736 (686, 786)	3 (–47, 54)
France[e]	490 (478, 502)	291 (273, 310)	938 (905, 971)	448 (415, 481)	655 (611, 700)	166 (121, 210)	783 (730, 836)	293 (240, 346)
Norway	695 (690, 700)	86 (68, 104)	856 (832, 880)	161 (137, 185)	703 (655, 751)	8 (–40, 55)	761 (709, 813)	66 (14, 118)
Sweden	587 (584, 590)	194 (176, 213)	870 (844, 895)	283 (257, 308)	717 (668, 766)	130 (81, 179)	774 (721, 827)	187 (134, 240)
Switzerland	589 (586, 593)	192 (174, 210)	874 (849, 899)	285 (260, 310)	615 (573, 657)	26 (–16, 68)	663 (618, 708)	74 (29, 119)

Notes. CI: confidence interval. [a] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years). [b] The observed or expected US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [c] The impact of differences in educational distribution was assessed by estimating the US mortality disadvantage if the educational distribution in the United States was replaced by that in each Western European country. [d] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage if the educational disparities in mortality in the United States were replaced by those in each Western European country. [e] For each country except France, the all-cause mortality rate is the sum of the cause-specific mortality rates. Because cause-specific mortality data were not available for the French population, the all-cause mortality rate was included in this table. [f] The CIs calculated for the expected US mortality rates and disadvantages were based on a Monte Carlo simulation assuming a normal distribution with 10,000 samples.

TABLE J – Mortality disadvantage for US black women: United States and 7 European countries, 1989–2003

Countries	Observed		Scenario 1: Expected with European educational distribution[c]		Scenario 2: Expected with European relative risks of mortality by education[d]		Scenario 3: Expected with European educational distribution[c] and European relative risks of mortality by education[d]	
	Mortality rate[a] (95% CI)	US mortality disadvantage[b] (95% CI)	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]
United States	1142 (1090, 1195)							
Belgium	766 (761, 770)	377 (324, 429)	1233 (1161, 1304)	467 (395, 539)	861 (676, 1,047)	95 (−90, 281)	927 (728, 1127)	162 (−38, 361)
Denmark	960 (953, 966)	183 (130, 235)	1168 (1109, 1228)	208 (149, 268)	969 (760, 1178)	9 (−199, 218)	997 (783, 1212)	37 (−177, 252)
Finland	733 (728, 737)	410 (357, 462)	1195 (1131, 1260)	463 (398, 527)	941 (738, 1143)	208 (6, 411)	985 (773, 1197)	252 (40, 465)
France[e]	490 (478, 502)	652 (600, 705)	1239 (1169, 1309)	749 (679, 819)	954 (748, 1160)	464 (258, 670)	1048 (823, 1274)	558 (333, 784)
Norway	695 (690, 700)	447 (394, 500)	1140 (1087, 1193)	445 (391, 498)	1015 (796, 1233)	320 (101, 538)	1019 (799, 1238)	324 (104, 543)
Sweden	587 (584, 590)	555 (503, 608)	1152 (1096, 1208)	565 (509, 621)	1025 (804, 1245)	438 (217, 658)	1035 (812, 1258)	448 (225, 671)
Switzerland	589 (586, 593)	553 (500, 606)	1167 (1112, 1222)	578 (523, 632)	876 (688, 1065)	287 (99, 476)	890 (699, 1081)	301 (109, 492)

Notes. CI: confidence interval. [a] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years). [b] The observed or expected US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [c] The impact of differences in educational distribution was assessed by estimating the US mortality disadvantage if the educational distribution in the United States was replaced by that in each Western European country. [d] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage if the educational disparities in mortality in the United States were replaced by those in each Western European country. [e] For each country except France, the all-cause mortality rate is the sum of the cause-specific mortality rates. Because cause-specific mortality data were not available for the French population, the all-cause mortality rate was included in this table. [f] The CIs calculated for the expected US mortality rates and disadvantages were based on a Monte Carlo simulation assuming a normal distribution with 10,000 samples.

TABLE K – **Mortality disadvantage for US white men: United States and 7 European countries, 1989–2003**

	Observed		Scenario 1: Expected with European educational distribution[c]		Scenario 2: Expected with European relative risks of mortality by education[d]		Scenario 3: Expected with European educational distribution[c] and European relative risks of mortality by education[d]	
Countries	Mortality rate[a] (95% CI)	US mortality disadvantage[b] (95% CI)	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]
United States	1248 (1124, 1273)							
Belgium	1481 (1473, 1488)	–232 (–257, –208)	1507 (1469, 1545)	26 (–12, 65)	1044 (990, 1098)	–437 (–491, –383)	1192 (1130, 1253)	–289 (–350, –227)
Denmark	1508 (1499, 1517)	–259 (–284, –234)	1383 (1354, 1412)	–124 (–153, –96)	1130 (1072, 1189)	–377 (–435, –319)	1206 (1144, 1268)	–302 (–364, –239)
Finland	1528 (1521, 1536)	–280 (–305, –255)	1473 (1437, 1509)	–55 (–91, –19)	1184 (1122, 1245)	–345 (–406, –283)	1322 (1254, 1391)	–206 (–274, –138)
France[e]	1132 (1113, 1152)	116 (91, 141)	1492 (1457, 1528)	360 (324, 396)	1250 (1185, 1315)	118 (53, 183)	1487 (1410, 1564)	355 (278, 432)
Norway	1272 (1265, 1279)	–24 (–49, 1)	1353 (1326, 1380)	81 (53, 108)	1112 (1054, 1169)	–160 (–218, –103)	1180 (1119, 1241)	–92 (–153, –31)
Sweden	1026 (1022, 1030)	222 (197, 247)	1415 (1384, 1445)	388 (358, 419)	1086 (1030, 1142)	60 (4, 116)	1178 (1117, 1239)	152 (91, 213)
Switzerland	1165 (1159, 1171)	83 (59, 108)	1277 (1252, 1302)	112 (87, 137)	1117 (1060, 1175)	–48 (–105, 10)	1138 (1079, 1197)	–27 (–86, 32)

Notes. CI: confidence interval. [a] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years). [b] The observed or expected US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [c] The impact of differences in educational distribution was assessed by estimating the US mortality disadvantage if the educational distribution in the United States was replaced by that in each Western European country. [d] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage if the educational disparities in mortality in the United States were replaced by those in each Western European country. [e] For each country except France, the all-cause mortality rate is the sum of the cause-specific mortality rates. Because cause-specific mortality data were not available for the French population, the all-cause mortality rate was included in this table. [f] The CIs calculated for the expected US mortality rates and disadvantages were based on a Monte Carlo simulation assuming a normal distribution with 10,000 samples.

TABLE L – Mortality disadvantage for US black men: United States and 7 European countries, 1989–2003

	Observed		Scenario 1: Expected with European educational distribution[c]		Scenario 2: Expected with European relative risks of mortality by education[d]		Scenario 3: Expected with European educational distribution[c] and European relative risks of mortality by education[d]	
Countries	Mortality rate[a] (95% CI)	US mortality disadvantage[b] (95% CI)	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]	US mortality rate[a] (95% CI)[f]	US mortality disadvantage[b] (95% CI)[f]
United States	1802 (1713, 1891)							
Belgium	1481 (1473, 1488)	321 (232, 410)	1920 (1817, 2024)	440 (336, 543)	1507 (1196, 1819)	27 (−284, 338)	1576 (1251, 1901)	95 (−230, 420)
Denmark	1508 (1499, 1517)	294 (206, 383)	1761 (1673, 1848)	253 (165, 340)	1632 (1295, 1969)	125 (−212, 461)	1597 (1267, 1926)	89 (−240, 419)
Finland	1528 (1521, 1536)	274 (185, 362)	1871 (1771, 1970)	342 (243, 442)	1724 (1368, 2080)	196 (−160, 551)	1743 (1383, 2103)	215 (−145, 575)
France[e]	1132 (1113, 1152)	669 (581, 758)	1893 (1796, 1990)	761 (664, 857)	1871 (1485, 2258)	739 (352, 1125)	1957 (1553, 2362)	825 (420, 1229)
Norway	1272 (1265, 1279)	530 (441, 618)	1714 (1628, 1800)	442 (356, 528)	1619 (1285, 1953)	347 (12, 681)	1558 (1236, 1879)	285 (−36, 607)
Sweden	1026 (1022, 1030)	776 (687, 864)	1796 (1707, 1884)	769 (681, 858)	1566 (1243, 1889)	540 (216, 863)	1557 (1236, 1879)	531 (210, 853)
Switzerland	1165 (1159, 1171)	637 (548, 726)	1619 (1531, 1707)	454 (366, 542)	1643 (1304, 1982)	478 (139, 817)	1503 (1192, 1813)	338 (27, 648)

Notes. CI: confidence interval. [a] Rates have been directly standardized toward the US 1995 intercensal population (in deaths per 100,000 person-years). [b] The observed or expected US mortality disadvantage is the absolute difference between the US standardized mortality rate and that of each Western European country (in deaths per 100,000 person-years). [c] The impact of differences in educational distribution was assessed by estimating the US mortality disadvantage if the educational distribution in the United States was replaced by that in each Western European country. [d] The impact of differences in educational inequalities in mortality was assessed by estimating the US mortality disadvantage if the educational disparities in mortality in the United States were replaced by those in each Western European country. [e] For each country except France, the all-cause mortality rate is the sum of the cause-specific mortality rates. Because cause-specific mortality data were not available for the French population, the all-cause mortality rate was included in this table. [f] The CIs calculated for the expected US mortality rates and disadvantages were based on a Monte Carlo simulation assuming a normal distribution with 10,000 samples.

Chapter 3

Mortality differences by education: Comparing the United States with seven European countries for the early 1990s and the 2000s

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ABSTRACT

Objectives. To estimate all-cause and cause-specific mortality rates by educational level for the early 1990s and early 2000s and compare these for the United States (US) and 7 European countries.

Methods. Poisson models were used to calculate age-standardized mortality rates for men and women aged 35 to 74 years for the period 1989 to 2006. For the US, data came from the National Health Interview Survey linked to the National Death Index. For Belgium, Denmark, Finland, Italy (Turin), Slovenia, Sweden, Switzerland, data from mortality registries were used.

Results. Absolute inequalities in mortality increased significantly more in the United States than in Europe due to increasing mortality among lower educated women. In the European countries, mortality declines were shared equally by educational groups. The increasing mortality among low educated Americans was primarily driven by an increase in mortality from diseases other than cardiovascular disease or cancer.

Conclusions. Increasing mortality among low educated individuals was only observed in the US, and resulted in even larger social disparities in mortality in the United States than those observed in Europe.

INTRODUCTION

The lower life expectancy of Americans, as compared with that of adults from other high-income countries, has received much attention in the last two decades. The National Research Council and the Institute of Medicine devoted multiple reports to international comparisons between the United States (US) and other high-income countries to study this US disadvantage in life expectancy and mortality.[1–3] These reports showed that the US health disadvantage affects Americans of all ages, is more pronounced among women than among men, is observed for multiple health outcomes, and increased over the past three decades.[3] Suggested explanations for the US health disadvantage include differences in the public health and medical care system (e.g., access to affordable care), individual health-related behaviors (e.g., smoking or obesity), factors related to the physical and social environment (e.g., built environment, or residential and racial segregation), and social factors (e.g., education or income).[1–4] Recently, Case & Deaton[5,6] reported an increase in all-cause mortality of middle-aged white non-Hispanic Americans between 1999 and 2013, which may suggest an increasing US health disadvantage if mortality increases are not observed among other high-income countries.

Since the 1960s, educational gradients in health and mortality have widened over time in the United States.[7–15] A widening of the gradient has been observed for both men and women. Early findings were more consistent for men than for women, but the widening was found to be stronger for women than for men in more recent decades.[5,10,15–19] These widening educational inequalities in mortality reflect decreasing mortality rates among the high educated and non-improving, or even increasing, mortality among the low educated.[11–13,18–20] Although some of the previous findings have been challenged,[16,21,22] they do show a remarkable trend of mortality increases among non-Hispanic white Americans, urging a closer look at what might be causing this. A full explanation for the increasing mortality of low educated Americans is still lacking. On the one hand, compositional changes to the low educated group may explain these trends; as more men and women received higher education, those remaining in the lower educational group may be more negatively selected.[19] However, no consensus has been reached yet on how much of the widening educational gap in mortality can be explained by compositional changes.[10,15,18] On the other hand, the trend of widening educational differences may reflect a causal process; higher education may be increasingly necessary to obtain resources that improve health, such as employment or income.[19]

Socioeconomic inequalities in health in Europe have received much attention ever since the Black report in England in 1980 showed mortality inequalities by occupational class. Relative educational inequalities in mortality have widened over time in many European countries,[23–25] indicating that, similar to the United States, educational gradients in mortality also seem to be persistent in Europe. Moreover, there are indications that these will not be eliminated any time soon.[26] However, absolute inequalities in mortality have not necessarily increased over time. For example, Mackenbach and colleagues[25] found that absolute mortality has declined more among low educated than high educated adults in many Northern, Western and Southern European countries in the 2000s. A narrowing of absolute inequalities has not been a rare occurrence in Europe, but it is not a universal trend. In a more recent study, Mackenbach and colleagues[27] found that there are no indications of an unfavorable mortality trend among low educated Europeans; they found improvements in the mortality rates of low educated adults in most European countries in recent years, and not a deterioration as observed among low educated Americans.

This study examines absolute and relative inequalities in all-cause mortality and mortality from 4 major causes of death by education among American and European adults for the early 1990s and 2000s. To our knowledge, no previous study has yet systematically investigated changes in educational inequalities in mortality for the US and several European countries by directly comparing them. We were especially interested in how mortality trends among low educated Europeans may differ from those observed among low educated Americans. If this unfavorable mortality trend among lower educated men and women is observed in the US and not, or to a lesser extent, in Europe, it may indicate the increasing disparities may be due to US context specific conditions. Additionally the cause-specific analysis may shed some light on which conditions may be of importance. Compared to Europe, the United States is characterized by larger income inequalities, greater residential and racial segregation, non-universal health care access, less generous social protection policies (e.g., employment protection and support programs, housing programs, or income transfer programs), which may disproportionally disadvantage lower educated Americans. All of these may have led to decreasing levels of economic and social well-being of lower educated Americans. Due to a more egalitarian environment in Europe, this pattern may be less dramatic for lower educated Europeans. However, if increasing mortality among lower educated men and women is observed for both the US and Europe, it may reflect a more general pattern rather than context specific conditions (e.g., compositional changes to the lower educated group).

DATA AND METHODS

Data from 6 waves (1989–1991 to represent 1990, and 1999–2001 to represent 2000) of the US National Health Interview Survey (NHIS), provided by IPUMS Health Surveys, were used.[28] The NHIS is a survey of the non-institutionalized population of the United States. Individuals in each period were linked to 5 year mortality follow-up through linkage of the NHIS with the National Death Index. We focused on middle-aged and older individuals and included individuals aged 35 years and older. However, we excluded the population aged 75 years and older from our sample as mortality at older ages is likely to be underestimated as the institutionalized population is excluded from the NHIS sample. The US data included 291,808 individuals aged 35 to 74 years at death or end of follow-up, whichever came first (164,441 in the 1990s and 127,367 in the 2000s), and 10,980 deaths during the mortality follow-up (6573 in the 1990s and 4407 in the 2000s). Analyses were done separately for non-Hispanic whites and non-Hispanic blacks to take into account the substantial racial differences in mortality existing in the US.[29]

For the European countries we used census data from the early 1990s and 2000s linked to national mortality registries with a follow-up of 5 years, collected within the DEMETRIQ project. For Belgium, Denmark, Slovenia, Sweden, and Switzerland, our data covered the entire national populations. For Finland, we used an 11% representative sample of the national population in which 80% of all deaths were oversampled. For Italy, urban data from Turin were used. Corresponding with the sample selection of the US data, Europeans aged 35 to 74 years at death or end of follow-up were included in this study. In total, the European data included 169,704,797 person-years (78,959,885 in the 1990s and 90,744,912 in the 2000s) and 1,274,343 deaths in the 5 years of mortality follow-up (672,210 in the 1990s and 602,133 in the 2000s).

Data were available in aggregated form for the European countries; it provided us with the number of individuals, number of person-years, and number of deaths for specific categories of the population, e.g., based on sex, five year age group, and educational level. We decided to also aggregate the individual-level US data so that the same estimation models could be used for the United States and Europe. As our results are still only based on a sample of the US population, we used the sample weights divided by its mean for the aggregation to allow for an appropriate amount of uncertainty reflected in our estimates.

We calculated mortality rates by educational level, which was measured by the number of years of completed schooling in the US and by the highest level of educational attainment in Europe. Educational levels in the United States and Europe were harmonized to correspond to levels defined in the International Standard Classification of Education (ISCED).[30] Three levels of educational attainment were distinguished: lower secondary or less education (ISCED levels 0 to 2; ≤11 years of education in the US), upper secondary education (ISCED levels 3 and 4; 12–15 years of education in the US), and tertiary or more education (ISCED levels 5 and 6; ≥16 years of education in the US).

All-cause mortality and mortality from cancer, cardiovascular disease, other diseases than cancer or cardiovascular disease, and external causes were estimated for all countries. There were two exceptions; cause-specific mortality data were not available for Belgium, and data on mortality from external causes were not available for Slovenia. First, for each country and for the two time periods separately, age-standardized mortality rates per 100,000 person-years by educational level were calculated using Poisson models. The mortality rates were age-standardized towards the US intercensal population on April 1, 2000. Then, we calculated differences in mortality rates between educational groups for each time period, i.e. mortality rate differences and rate ratios, and also changes in mortality rates by education over time. Furthermore, more advanced measures of educational inequalities, namely the relative index of inequality and slope index of inequality, were calculated to take into account the population size of each educational group as well as its relative disadvantage. All calculations were done separately for men and women.

RESULTS

Educational distribution

Overall, a more favorable educational distribution was observed in the US than in the European countries; a noticeably smaller proportion of the population was low educated in the US than in Europe (Table 1). A higher average educational level was observed for American men and women in both the 1990s and 2000s. In all countries, the educational distribution improved over time; the proportion of low educated individuals decreased whereas the proportion of mid and high educated men and women increased.

All-cause mortality

In both the early 1990s and 2000s, mortality rates for US men and women were within the range of those for European men and women (Table 1). All-cause mortality declined over time for all countries, however, a closer look at mortality rates by educational level showed a diverging picture among the countries; low educated Americans had higher mortality rates than their European counterparts, but the mortality rates of high educated Americans were comparable to those of high educated Europeans. Hence, mortality improved for mid and high educated Americans, but not for those with low education between the early 1990s and 2000s (Figure 1, Table 1). Mortality increases were observed among low educated non-Hispanic white American men (188, 95% CI: 33, 342) and women (174, 95% CI: 46, 303). For low educated Europeans, on the other hand, mortality decreases were observed that ranged from 156 (95% CI: 144, 168; Sweden) to 261 (95% CI: 239, 284; Switzerland) among men, and from 33 (95% CI: 24, 42; Sweden) to 128 (95% CI: 111, 144; Slovenia) among women.

Cause-specific mortality

The increase in all-cause mortality between the 1990s and 2000s of low educated white Americans was largely due to increased mortality from diseases other than cancer or cardiovascular disease (Table 2); mortality from other diseases increased with 214 per 100,000 person-years (95% CI: 130, 298) for men, and with 143 (95% CI: 130, 298) for women. For mid educated US white women, an increase of 47 (95% CI: 25, 68) in mortality from diseases other than cancer or cardiovascular disease was also observed.

Cause-specific mortality generally decreased between the early 1990s and 2000s among European adults. Nevertheless, some mortality increases were observed: mortality from other diseases increased for low educated Danish women (20, 95% CI: 13, 26), Finnish men (24, 95% CI: 17, 32) and women (20, 95% CI: 15, 25), and Swedish women (10, 95% CI: 6, 15), and for mid educated Finnish men (14, 95% CI: 5, 24) and women (mid: 8, 95% CI: 2, 13), and Swedish women (7, 95% CI: 3, 11). Overall, Americans were worse off than Europeans as they experienced larger increases in mortality than their European counterparts, but also smaller decreases when experiencing mortality decreases.

Mortality rate ratios and mortality rate differences

The mortality rate ratios of low and mid educated men and women were larger in the US than in the European countries (Table 3); for example, the mortality rate ratio was 3.32 (95% CI: 2.89, 3.82) for low educated US white men in the 1990s, but it ranged from 1.68 (95% CI: 1.55, 1.83; Italy) to 2.34 (95% CI: 2.23, 2.46; Slovenia) for European men. Between the 1990s and 2000s, mortality rate ratios increased for low, but not mid, educated US white men and women. The mortality rate ratios increased for low educated men in all European countries, but for low educated women only in Belgium, Finland, and Sweden. For mid educated individuals, the mortality rate ratio increased for men in Belgium, Finland, Slovenia, Sweden, and Switzerland and for women in Belgium, Denmark, Finland, and Sweden. Overall, we observed increasing relative educational inequalities in mortality over time for both the US and Europe. Nevertheless, the mortality rate ratios were higher among Americans in both time periods.

Mortality rate differences for low educated men and women (i.e. the absolute difference in mortality between low and high educated individuals) were generally larger in the US than in the European countries. Over time, these differences increased for US white and Belgian men, but decreased for Finnish, Slovenian, Swedish, and Swiss men. Increases in mortality rate differences were observed for US white, US other, Belgian, Danish, Finnish, and Swedish women. Increases were thus not limited to only the US, but they were larger for US men and women than their European counterparts, widening the already existing US disadvantage.

Relative index of inequality

The relative index of inequality (RII), a measure of inequality that takes into account the population size of each educational group as well as its relative disadvantage, was higher in the US than in the European countries (Figure 2). Between the 1990s and the 2000s, the RII increased for US white, Belgian, Danish, Finnish, Italian, Swedish men and women, as well as Slovenian women and Swiss men. However, it decreased for Italian women. The largest increases were observed for US white men (from 3.41 to 4.46) and women (from 3.11 to 5.08).

TABLE 1 – Educational distribution and all-cause mortality rates by education for men and women aged 35 to 74 years in the United States (by race) and 6 European countries, early 1990s and early 2000s.

	US, all	US, whites	US, blacks	US, others	Belgium
Men, 1990s					
Educational distribution, percent					
Low education	18	15	30	34	62
Mid education	55	56	56	43	21
High education	27	29	13	23	17
Mortality rates (95% CI)					
Low education	1278 (1211, 1346)	1251 (1172, 1330)	1773 (1560, 1986)	891 (741, 1041)	1250 (1242, 1258)
Mid education	810 (773, 848)	809 (768, 849)	926 (786, 1066)	608 (485, 730)	1072 (1056, 1088)
High education	477 (435, 519)	472 (428, 516)	616 (383, 849)	440 (NC)	833 (817, 850)
All	849 (822, 876)	818 (789, 848)	1246 (1136, 1356)	689 (605, 773)	1174 (1167, 1181)
2000s					
Educational distribution, percent					
Low education	13	9	17	32	46
Mid education	58	60	67	45	27
High education	29	31	16	23	27
Mortality rates (95% CI)					
Low education	1279 (1183, 1375)	1439 (1306, 1572)	1535 (1248, 1823)	795 (649, 941)	1035 (1027, 1042)
Mid education	770 (730, 810)	729 (686, 773)	1095 (945, 1246)	707 (580, 835)	740 (729, 750)
High education	437 (395, 479)	433 (388, 479)	702 (466, 937)	315 (201, 428)	546 (537, 555)
All	761 (731, 791)	728 (695, 760)	1146 (1027, 1265)	650 (571, 729)	867 (862, 872)
Women, 1990s					
Educational distribution, percent					
Low education	18	14	29	37	70
Mid education	62	65	58	46	17
High education	20	22	13	17	12
Mortality rates (95% CI)					
Low education	783 (733, 833)	785 (723, 846)	1072 (922, 1223)	490 (393, 587)	584 (579, 589)
Mid education	476 (451, 501)	470 (443, 497)	626 (525, 726)	310 (232, 389)	602 (588, 615)
High education	328 (287, 370)	337 (291, 382)	360 (201, 519)	213 (NC)	550 (534, 566)
All	529 (509, 549)	512 (490, 534)	774 (697, 852)	377 (320, 434)	583 (579, 588)
2000s					
Educational distribution, percent					
Low education	12	7	17	32	47
Mid education	62	64	67	48	26
High education	26	28	16	20	27
Mortality rates (95% CI)					
Low education	861 (784, 938)	959 (846, 1071)	1159 (935, 1383)	543 (434, 651)	550 (545, 556)
Mid education	459 (432, 487)	441 (411, 471)	715 (609, 821)	329 (251, 408)	400 (392, 407)
High education	269 (233, 305)	262 (223, 302)	514 (332, 696)	144 (NC)	300 (293, 307)
All	482 (459, 504)	455 (430, 480)	792 (705, 880)	384 (327, 442)	475 (472, 479)

Notes. CI: confidence interval. NC: not calculated, as the confidence interval could not be calculated due to low sample sizes.

Denmark	Finland	Turin, Italy	Slovenia	Sweden	Switzerland
46	49	65	70	40	18
36	29	23	17	39	57
17	22	11	13	21	25
1248 (1236, 1260)	1303 (1291, 1315)	914 (894, 933)	1537 (1514, 1560)	918 (909, 926)	1137 (1121, 1153)
1057 (1040, 1073)	1047 (1028, 1067)	712 (676, 748)	1031 (993, 1068)	759 (749, 769)	822 (813, 832)
731 (710, 751)	703 (686, 719)	594 (550 639)	720 (683, 757)	535 (522, 548)	597 (585, 610)
1137 (1128, 1146)	1154 (1145, 1163)	851 (836, 867)	1362 (1343, 1380)	809 (803, 814)	858 (851, 865)
36	34	53	29	29	14
42	38	31	56	45	54
22	27	15	15	26	33
1057 (1045, 1070)	1067 (1055, 1078)	680 (662, 698)	1313 (1288, 1337)	762 (754, 770)	876 (860, 891)
832 (820, 843)	841 (827, 854)	479 (455, 504)	873 (856, 890)	619 (612, 626)	610 (602, 618)
552 (538, 565)	520 (509, 531)	404 (373, 436)	560 (536, 585)	416 (408, 424)	409 (400, 418)
874 (867, 881)	878 (871, 885)	601 (587, 614)	983 (971, 996)	636 (632, 641)	605 (599, 611)
58	49	73	73	39	37
26	30	19	18	39	55
16	21	8	9	22	8
741 (733, 749)	540 (533, 547)	429 (417, 440)	634 (622, 646)	504 (498, 510)	459 (452, 466)
601 (587, 616)	417 (406, 428)	349 (322, 377)	503 (478, 527)	405 (398, 412)	360 (354, 366)
501 (482, 520)	355 (342, 368)	320 (277, 363)	396 (359, 434)	312 (302, 322)	338 (320, 356)
693 (686, 699)	492 (487, 497)	414 (404, 424)	604 (593, 614)	447 (443, 451)	408 (403, 412)
42	31	57	40	26	29
33	36	29	44	45	58
25	32	14	15	29	13
657 (649, 666)	477 (469, 484)	323 (312, 334)	506 (495, 518)	471 (465, 477)	384 (377, 391)
490 (480, 500)	350 (342, 358)	300 (279, 321)	356 (344, 368)	371 (365, 376)	290 (285, 296)
365 (354, 377)	263 (255, 271)	270 (240, 299)	283 (263, 303)	262 (256, 268)	263 (251, 275)
560 (554, 565)	392 (388, 397)	314 (305, 323)	431 (424, 439)	387 (383, 390)	326 (322, 330)

TABLE 2 – Absolute changes in mortality rates by education for men and women aged 35 to 74 in the United States and 6 European countries, between early 1990s and early 2000s

	US, all	US, whites	US, blacks	US, others	Belgium[a]
Men					
All-cause mortality					
Low education	1 (–116, 118)	188 (33, 342)	–238	–96 (–305, 113)	–215 (–226, –204)
Mid education	–40 (–95, 15)	–80 (–139, –20)	170 (–36, 375)	100 (–77, 277)	–332 (–352, –313)
High education	–40 (–99, 19)	–39 (–102, 25)	86 (–245, 417)	–125 (–310, 60)	–287 (–306, –268)
All	–88 (–128, –48)	–91 (–135, –47)	–100	–39 (–154, 77)	–307 (–316, –299)
Mortality from cardiovascular disease					
Low education	–69 (–136, –3)	–33 (–122, 55)	NC	–77 (–200, 46)	NA
Mid education	–45 (–77, –13)	–66 (–100, –32)	85 (–38, 208)	10 (–95, 115)	NA
High education	–37 (–71, –2.3)	–38 (–74, –1)	–74 (–276, 128)	–26 (–150, 99)	NA
All	–70 (–93, –46)	–78 (–104, –53)	NC	–38 (–108, 32)	NA
Cancer mortality					
Low education	–38 (–100, 25)	0 (–83, 83)	NC	28 (–76, 131)	NA
Mid education	–19 (–51, 12)	–24 (–59, 11)	16 (–97, 128)	21 (–75, 116)	NA
High education	0 (–35, 36)	6 (–33, 45)	–12 (–207, 183)	–36 (–127, 55)	NA
All	–34 (–57, –11)	–31 (–57, –5)	NC	7 (–53, 66)	NA
Mortality from other diseases					
Low education	110 (45, 176)	214 (130, 298)	NC	–38 (–155, 80)	NA
Mid education	25 (–3, 52)	11 (–18, 40)	89 (–21, 199)	57 (–39, 153)	NA
High education	–5 (–34, 23)	–5 (–35, 25)	168 (–0, 336)	–115 (–218, –11)	NA
All	17 (–3, 38)	21 (–1, 42)	NC	–19 (–82, 45)	NA
Mortality from external causes					
Low education	–1 (–36, 34)	7 (–41, 55)	NC	–8 (–72, 56)	NA
Mid education	0 (–15, 15)	0 (–17, 16)	–16 (–65, 33)	12 (–34, 57)	NA
High education	2 (–15, 18)	–2 (–20, 16)	–14 (–96, 67)	38 (1, 74)	NA
All	–2 (–13, 9)	–2 (–14, 10)	NC	11 (–19, 42)	NA
Women					
All-cause mortality					
Low education	78 (–14, 170)	174 (46, 303)	87 (–183, 356)	53 (–93, 198)	–34 (–41, –26)
Mid education	–17 (–54, 20)	–29 (–69, 12)	89 (–57, 235)	19 (–92, 130)	–202 (–218, –186)
High education	–59 (–115, –4)	–75 (–135, –14)	154 (–87, 396)	NC	–250 (–267, –232)
All	–47 (–77, –17)	–57 (–91, –24)	18 (–99, 134)	7 (–73, 88)	–119 (–125, –113)
Mortality from cardiovascular disease					
Low education	–23 (–72, 27)	–10 (–74, 55)	–22 (–182, 139)	–6 (–87, 75)	NA
Mid education	–25 (–44, –6)	–33 (–53, –13)	35 (–52, 123)	–16 (–71, 39)	NA
High education	–11 (–38, 16)	–24 (–52, 4)	132 (–19, 282)	NC	NA
All	–40 (–56, –24)	–47 (–64, –30)	–10 (–81, 62)	–17 (–61, 26)	NA
Cancer mortality					
Low education	6 (–47, 58)	37 (–37, 112)	33 (–107, 173)	–17 (–102, 68)	NA
Mid education	–43 (–66, –20)	–47 (–72, –21)	–25 (–107, 57)	7 (–62, 76)	NA
High education	–62 (–100, –23)	–65 (–109, –22)	–3 (–136, 130)	NC	NA
All	–46 (–64, –27)	–50 (–71, –29)	–22 (–84, 41)	–14 (–62, 35)	NA

Denmark	Finland	Turin, Italy	Slovenia[b]	Sweden	Switzerland
−191 (−208, −173)	−183 (−203, −163)	−233 (−260, −207)	−224 (−258, −191)	−156 (−144, −168)	−261 (−284, −239)
−225 (−245, −205)	−206 (−231, −183)	−233 (−277, −189)	−158 (−199, −116)	−140 (−153, −128)	−212 (−225, −200)
−179 (−204, −154)	−236 (−253, −219)	−190 (−245, −135)	−160 (−204, −115)	−119 (−134, −104)	−188 (−204, −173)
−263 (−275, −252)	−276 (−287, −265)	−251 (−272, −230)	−378 (−401, −356)	−172 (−180, −165)	−253 (−262, −244)
−151 (−160, −142)	−183 (−193, −173)	−111 (−125, −97)	−163 (−184, −142)	−127 (−134, −119)	−124 (−135, −112)
−142 (−154, −130)	−159 (−175, −143)	−123 (−149, −97)	−144 (−173, −115)	−97 (−104, −89)	−119 (−126, −112)
−81 (−95, −66)	−140 (−153, −126)	−98 (−130, −66)	−160 (−192, −128)	−82 (−92, −72)	−94 (−103, −85)
−159 (−165, −153)	−194 (−201, −187)	−116 (−127, −105)	−210 (−225, −196)	−123 (−128, −119)	−125 (−130, −120)
−35 (−44, −26)	−47 (−55, −40)	−71 (−88, −54)	−46 (−65, −26)	−17 (−23, −11)	−68 (−80, −56)
−43 (−55, −32)	−34 (−46, −21)	−53 (−81, −25)	−47 (−74, −19)	−24 (−31, −16)	−40 (−47, −33)
−36 (−50, −21)	−42 (−54, −31)	−60 (−95, −25)	−31 (−60, 1)	−23 (−32, −13)	−45 (−54, −36)
−49 (−55, −42)	−54 (−59, −48)	−78 (−91, −64)	−83 (−97, −70)	−25 (−29, −21)	−58 (−63, −53)
2 (−8, 12)	24 (17, 32)	−41 (−54, −28)	−14 (−36, 9)	−5 (−11, +0)	−26 (−39, −14)
−5 (−15, 5)	14 (5, 24)	−40 (−58, −22)	−2 (−26, 22)	−12 (−17, −6)	−32 (−38, −25)
−27 (−38, −15)	−3 (−10, 5)	−24 (−47, +0)	−33 (−58, −7)	−7 (−13, −1)	−30 (−38, −22)
−28 (−24, −22)	3 (−2, 8)	−45 (−55, −35)	−119 (−133, −105)	−14 (−17, −11)	−42 (−46, −37)
−23 (−28, −17)	−31 (−39, −23)	−10 (−17, −3)	NA	−5 (−10, −0)	−51 (−61, −42)
−20 (−25, −16)	−24 (−32, −15)	−17 (−28, −6)	NA	−8 (−12, −4)	−22 (−26, −18)
−26 (−32, −20)	−7 (−14, −0)	−8 (−22, 5)	NA	−8 (−12, −4)	−19 (−24, −14)
−27 (−30, −23)	−31 (−36, −27)	−12 (−18, 7)	NA	−10 (−13, −8)	−29 (−32, −26)
−84 (−95, −72)	−63 (−73, −53)	−105 (−121, −89)	−128 (−144, −111)	−33 (−42, −24)	−75 (−84, −65)
−112 (−129, −94)	−67 (−80, −53)	−50 (−84, −15)	−146 (−174, −119)	−34 (−43, −25)	−70 (−78, −61)
−135 (−157, −114)	−92 (−108, −77)	−50 (−103, 2)	−113 (−156, −70)	−50 (−62, −38)	−75 (−97, −53)
−138 (−146, −129)	−95 (−102, −88)	−94 (−108, −80)	−186 (−199, −173)	−53 (−58, −48)	−81 (−88, −74)
−49 (−54, −44)	−70 (−76, −65)	−46 (−53, −39)	−106 (−116, −96)	−36 (−41, −32)	−43 (−48, −39)
−39 (−47, −30)	−53 (−61, −45)	−33 (−49, −16)	−86 (−103, −68)	−25 (−30, −21)	−29 (−33, −26)
−32 (−42, −22)	−46 (−54, −38)	−25 (−50, −0)	−41 (−66, −15)	−18 (−24, −12)	−29 (−38, −19)
−58 (−62, −54)	−74 (−77, −70)	−44 (−50, −37)	−123 (−131, −115)	−37 (−40, −34)	−37 (−40, −34)
−28 (−36, −21)	−11 (−17, −5)	−32 (−43, −20)	−26 (−37, −16)	−2 (−8, 4)	−17 (−24, −11)
−43 (−54, −31)	−19 (−28, −11)	−5 (−30, 20)	−51 (−71, −31)	−7 (−14, −1)	−22 (−28, −17)
−60 (−75, −45)	−24 (−34, −14)	1 (−38, 39)	−37 (−70, −4)	−19 (−28, −10)	−28 (−43, −13)
−46 (−52, −40)	−19 (−23, −15)	−23 (−33, −13)	−34 (−44, −25)	−11 (−14, −7)	−24 (−29, −19)

TABLE 2 – **Absolute changes in mortality rates by education for men and women aged 35 to 74 in the United States and 6 European countries, between early 1990s and early 2000s (continued)**

	US, all	US, whites	US, blacks	US, others	Belgium[a]
Mortality from other diseases					
Low education	96 (43, 149)	143 (68, 218)	76 (−82, 235)	65 (−16, 146)	NA
Mid education	45 (25, 65)	47 (25, 68)	53 (−24, 130)	26 (−40, 92)	NA
High education	19 (−7, 44)	22 (−5, 49)	16 (−111, 144)	NC	NA
All	36 (19, 52)	37 (20, 55)	33 (−31, 96)	33 (−13, 79)	NA
Mortality from external causes					
Low education	4 (−16, 23)	7 (−24, 37)	−3 (−52, 47)	11 (−17, 39)	NA
Mid education	6 (−4, 15)	5 (−6, 16)	26 (−5, 57)	3 (−11, 18)	NA
High education	−3 (−16, 9)	−5 (−19, 10)	14 (−27, 54)	NC	NA
All	3 (−4, 10)	2 (−7, 10)	16 (−7, 39)	5 (−6, 17)	NA

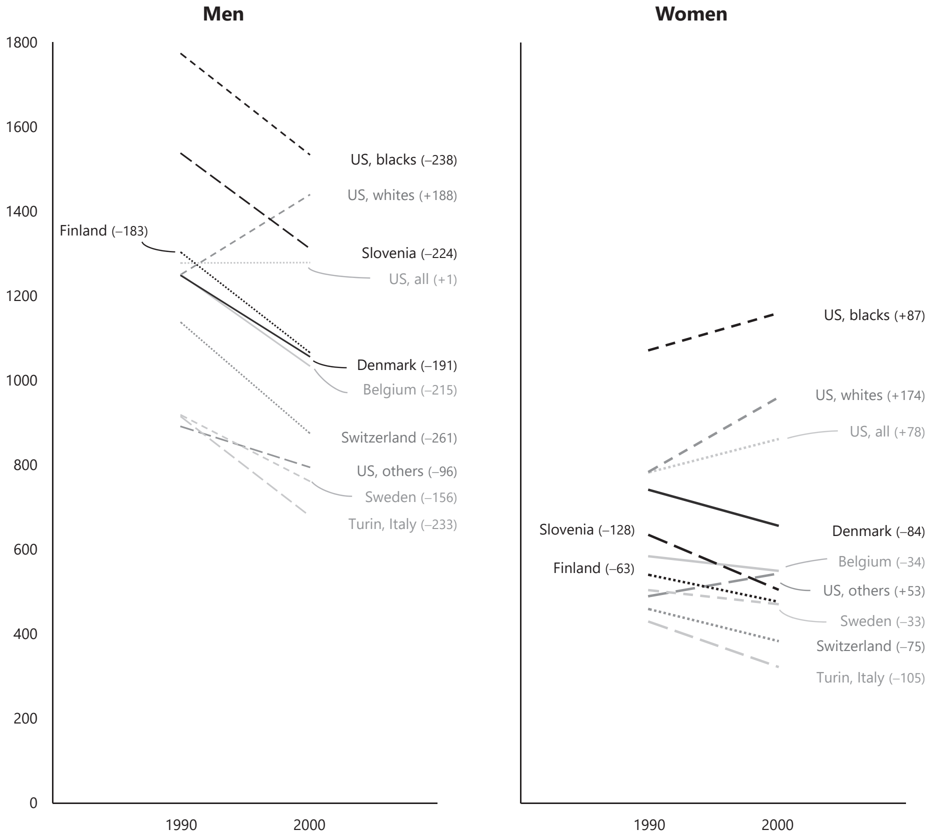

FIGURE 1 – **All-cause mortality rates for low educated men and women aged 35 to 74 years in the United States (by race) and in 7 European countries, early 1990s and early 2000s**

Notes. Mortality rates were age-standardized towards the 2000 US intercensal population (as of April 1, 2000) and presented per 100,000 person-years. Absolute change in mortality from 1990s to 2000s is presented in brackets.

Notes. CI: confidence interval; NC: not calculated due to low sample sizes; NA: not available. [a] For Belgium, no data on causes of death were available. [b] For Slovenia, no data on mortality from external causes were available.

Denmark	Finland	Turin, Italy	Slovenia[b]	Sweden	Switzerland
20 (13, 26)	20 (15, 25)	–20 (–28, –12)	–30 (–41, –20)	10 (6, 15)	–7 (–12, –2)
–9 (–18, –1)	8 (2, 13)	–5 (–19, 9)	–26 (–41, –12)	7 (3, 11)	–11 (–16, –7)
–11 (–21, –1)	–11 (–17, –5)	–4 (–24, 16)	–40 (–62, –18)	–2 (–7, 2)	–7 (–17, 4)
–10 (–14, –5)	2 (–1, 5)	–18 (–24, –11)	–62 (–69, –54)	2 (–0, 4)	–12 (–16, –9)
–19 (–22, –16)	–8 (–12, 3)	–8 (–12, –4)	NA	–4 (–6, –1)	–5 (–8, –2)
–17 (–21, –14)	–1 (–6, 3)	–8 (–15, +0)	NA	–9 (–11, –6)	–7 (–9, –4)
–19 (–24, –14)	0 (–4, 4)	–19 (–33, –6)	NA	–8 (–11, –4)	–11 (–18, –5)
–20 (–22, –17)	–4 (–7, –2)	–9 (–12, –6)	NA	–7 (–9, –6)	–8 (–10, –5)

The slope index of inequality (SII) was generally also higher for Americans than Europeans (results in supplemental materials). Over time, the slope index of inequality (SII) decreased for men in most countries, except for US white and Belgian men. For women, the SII increased for US white, US other, Belgian, Denmark, Finland, and Swedish women.

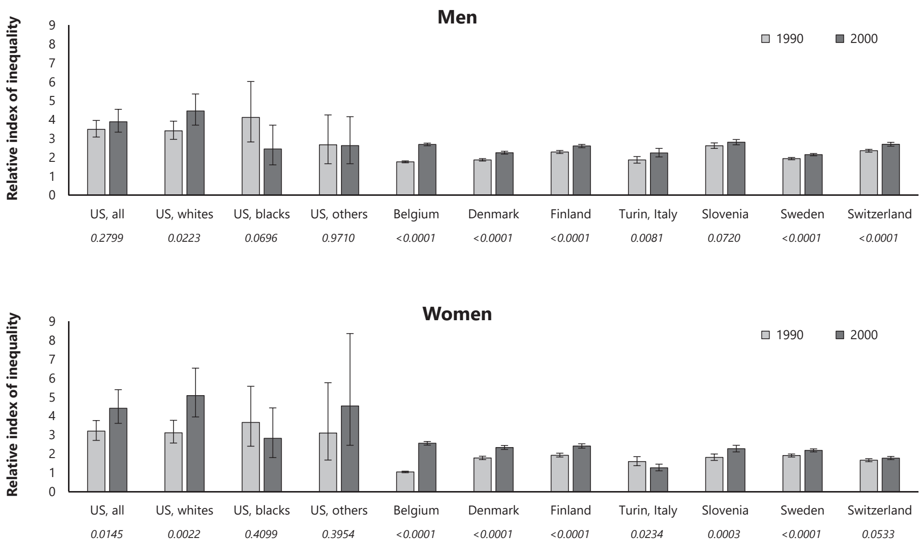

FIGURE 2 – **Relative index of inequality for men and women aged 35 to 74 years in the United States (by race) and 6 European countries, early 1990s and 2000s.**
Note. The italic numbers are the *p* values associated with the difference between the two time periods for each country.

TABLE 3 – Mortality rate differences and mortality rate ratios for men and women aged 35 to 74 in the United States and 6 European countries, early 1990s and early 2000s

	US, all	US, whites	US, blacks	US, others	Belgium
Men, 1990s					
Mortality rate ratios (95% CI)					
Low vs. high	2.68 (2.42, 2.97)	2.65 (2.37, 2.97)	2.88 (1.93, 4.30)	2.03 (1.40, 2.94)	1.50 (1.47, 1.53)
Mid vs. high	1.70 (1.54, 1.87)	1.71 (1.54, 1.91)	1.50 (1.00, 2.25)	1.38 (0.94, 2.03)	1.29 (1.26, 1.32)
Mortality rate differences (95% CI)					
Low vs. high	801 (721, 881)	779 (688, 870)	1157 (837, 1477)	452 (242, 661)	417 (398, 435)
Mid vs. high	333 (277, 389)	337 (277, 397)	310 (41, 580)	168 (–20, 356)	239 (216, 262)
2000s					
Mortality rate ratios (95% CI)					
Low vs. high	2.93 (2.59, 3.31)	3.32 (2.89, 3.82)	2.19 (1.49, 3.22)	2.53 (1.69, 3.79)	1.90 (1.86, 1.93)
Mid vs. high	1.76 (1.58, 1.96)	1.68 (1.49, 1.90)	1.56 (1.09, 2.24)	2.25 (1.50, 3.36)	1.35 (1.33, 1.38)
Mortality rate differences (95% CI)					
Low vs. high	842 (737, 947)	1005 (865, 1146)	834 (459, 1208)	481 (296, 665)	489 (477, 501)
Mid vs. high	333 (275, 391)	296 (234, 358)	394 (116, 671)	393 (223, 562)	194 (180, 208)
Comparing 2000s to 1990s					
Mortality rate ratios (95% CI) [a]					
Low vs. high	p=0.2803	p=0.0144	p=0.3335	p=0.4319	p<0.0001
Mid vs. high	p=0.6241	p=0.8268	p=0.8927	p=0.0857	p=0.0021
Mortality rate differences (95% CI)					
Low vs. high	41 (–91, 173)	226 (59, 394)	–323 (–816, 169)	29 (–250, 308)	72 (50, 94)
Mid vs. high	0 (–81, 81)	–41 (–127, 46)	84 (–303, 470)	225 (–28, 478)	–45 (–72, –18)
Women, 1990s					
Mortality rate ratios (95% CI)					
Low vs. high	2.38 (2.07, 2.75)	2.33 (1.99, 2.73)	2.98 (1.87, 4.74)	2.30 (1.30, 4.06)	1.06 (1.03, 1.10)
Mid vs. high	1.45 (1.26, 1.66)	1.40 (1.20, 1.62)	1.74 (1.09, 2.77)	1.46 (0.81, 2.62)	1.09 (1.06, 1.14)
Mortality rate differences (95% CI)					
Low vs. high	455 (389, 520)	448 (371, 525)	712 (492, 933)	276 (126, 426)	34 (17, 51)
Mid vs. high	148 (100, 196)	133 (80, 187)	265 (79, 452)	97 (–40, 234)	52 (31, 73)
2000s					
Mortality rate ratios (95% CI)					
Low vs. high	3.20 (2.72, 3.77)	3.66 (3.01, 4.43)	2.25 (1.50, 3.38)	3.76 (2.00, 7.05)	1.84 (1.79, 1.88)
Mid vs. high	1.71 (1.47, 1.98)	1.68 (1.43, 1.99)	1.39 (0.95, 2.03)	2.28 (1.21, 4.31)	1.33 (1.29, 1.37)
Mortality rate differences (95% CI)					
Low vs. high	592 (507, 678)	696 (576, 817)	645 (354, 936)	398 (259, 537)	250 (242, 259)
Mid vs. high	190 (145, 236)	179 (129, 229)	200 (–8, 409)	185 (69, 300)	100 (89, 110)
Comparing 2000s to 1990s					
Mortality rate ratios (95% CI) [a]					
Low vs. high	p=0.0077	p=0.0004	p=0.3765	p=0.2563	p<0.0001
Mid vs. high	p=0.1121	p=0.1007	p=0.4683	p=0.3096	p<0.0001
Mortality rate differences (95% CI)					
Low vs. high	137 (30, 246)	248 (105, 391)	–67 (–433, 298)	122 (–83, 326)	216 (197, 235)
Mid vs. high	42 (–24, 109)	45 (–28, 118)	–65 (–345, 215)	88 (–91, 267)	48 (24, 71)

Note. CI: confidence interval. [a] These *p* values are associated with the change in the mortality rate ratios for low and mid educated men and women.

Denmark	Finland	Turin, Italy	Slovenia	Sweden	Switzerland
1.71 (1.66, 176)	1.85 (1.81, 1.90)	1.54 (1.42, 1.66)	2.13 (2.02, 2.25)	1.72 (1.67, 1.76)	1.90 (1.85, 1.95)
1.45 (1.40, 1.49)	1.49 (1.45, 1.54)	1.20 (1.10, 1.31)	1.43 (1.34, 1.52)	1.42 (1.38, 1.46)	1.38 (1.34, 1.41)
517 (492, 542)	600 (580, 621)	319 (271, 368)	817 (774, 860)	383 (367, 398)	540 (519, 560)
326 (300, 352)	345 (319, 371)	118 (61, 175)	311 (258, 363)	224 (208, 240)	224 (209, 241)
1.92 (1.87, 1.97)	2.05 (2.00, 2.10)	1.68 (1.55, 1.83)	2.34 (2.23, 2.46)	1.83 (1.79, 1.87)	2.14 (2.08, 2.20)
1.51 (1.47, 1.55)	1.62 (1.58, 1.66)	1.19 (1.08, 1.30)	1.56 (1.48, 1.63)	1.49 (1.45, 1.52)	1.49 (1.45, 1.53)
506 (487, 524)	547 (531, 563)	276 (239, 312)	752 (717, 787)	346 (334, 357)	467 (448, 485)
280 (263, 298)	321 (304, 338)	75 (35, 115)	312 (282, 342)	203 (192, 214)	201 (189, 213)
p<0.0001	*p*<0.0001	*p*=0.1202	*p*=0.0109	*p*=0.0002	*p*<0.0001
p=0.0505	*p*=0.0001	*p*=0.8689	*p*=0.0365	*p*=0.0097	*p*<0.0001
–11 (–42, 19)	–53 (–80, –27)	–43 (–104, 17)	–65 (–120, –10)	–37 (–56, –18)	–73 (–101, –46)
–46 (–77, –14)	–24 (–55, 7)	–43 (–113, 27)	2 (–59, 62)	–22 (–41, –2)	–24 (–44, –4)
1.48 (1.42, 1.54)	1.52 (1.46, 1.58)	1.34 (1.17, 1.54)	1.60 (1.45, 1.76)	1.61 (1.56, 1.67)	1.36 (1.29, 1.44)
1.20 (1.15, 1.25)	1.17 (1.12, 1.23)	1.09 (0.93, 1.28)	1.27 (1.14, 1.41)	1.30 (1.25, 1.35)	1.07 (1.01, 1.13)
240 (219, 261)	185 (170, 200)	109 (64, 154)	238 (198, 277)	192 (180, 204)	121 (102, 141)
100 (77, 124)	62 (45, 78)	29 (–22, 81)	106 (62, 151)	93 (80, 105)	22 (3, 41)
1.80 (1.74, 1.86)	1.81 (1.75, 1.88)	1.20 (1.07, 1.35)	1.79 (1.66, 1.93)	1.80 (1.75, 1.85)	1.46 (1.39, 1.54)
1.34 (1.29, 1.39)	1.33 (1.28, 1.38)	1.11 (0.98, 1.26)	1.26 (1.16, 1.36)	1.42 (1.38, 1.46)	1.11 (1.05, 1.16)
292 (278, 306)	214 (202, 225)	54 (22, 86)	223 (200, 247)	209 (200, 218)	122 (108, 136)
124 (109, 139)	87 (76, 99)	30 (–6, 66)	73 (50, 96)	109 (100, 117)	28 (15, 41)
p<0.0001	*p*<0.0001	*p*=0.2288	*p*=0.0753	*p*<0.0001	*p*=0.0504
p=0.0002	*p*<0.0001	*p*=0.8678	*p*=0.9013	*p*=0.0002	*p*=0.3331
52 (26, 77)	29 (10, 48)	–55 (–110, 0)	–15 (–60, 31)	17 (2, 32)	1 (–23, 24)
24 (–4, 52)	26 (6, 46)	0 (–62, 63)	–33 (–84, 17)	16 (1, 31)	6 (–18, 29)

DISCUSSION

Absolute and relative inequalities in all-cause mortality were generally larger in the US than in the European countries; for both men and women, and both in the 1990s and the 2000s. Relative inequalities increased in the US and in Europe, also when accounting for changes in the educational distribution. However absolute inequalities in mortality increased significantly more in the United States than in Europe. This results from an increase in mortality among lower educated women that was unique to the United States, primarily driven by an increase in mortality from diseases other than cancer or cardiovascular disease. Mortality declines in the European countries, however, were shared equally by the educational groups.

Methodological considerations

Our mortality estimates may have been affected by differences in methods of data collection, baseline periods, follow-up periods, and the population covered for the different countries in this cross-national context. The European data generally included total populations, but the US data (NHIS) excluded the institutionalized population, e.g., individuals living in nursing homes. As institutionalized individuals are generally less healthy than those living in the community, we likely underestimated US mortality compared to European mortality, and thus also the US mortality disadvantage.

Educational attainment was measured based on years of schooling for Americans and based on ISCED highest educational attainment levels for Europeans. Overall, Americans had higher levels of education than their European counterparts. This finding is in line with other sources, such as the Organisation for Economic Co-operation and Development.[31] However, some of the variation in educational disparities in mortality may be due to cross-national differences in educational systems, practices, curricula, and other aspects of education that are not taken into account by the ISCED levels. Nevertheless, the difference between the US and Europe seem too large to be only explained by differences in educational classification or educational system.

Interpretation

Relative inequalities in mortality (measured as rate ratios between lower and high educated individuals) increased for almost all European men and women between the early 1990s and 2000s. But over time, absolute inequalities (measured as rate differences) decreased for men in many of these countries but not for women (although they also did not increase). This persistence of health inequalities was not unexpected as it has been previously reported.[32] Overall a favorable trend of mortality declines was observed in Europe. These decreases in mortality were shared by lower and higher educated individuals, which is in line with previous findings.[33] Possible explanations for these universal mortality decreases in Europe are continuous improvements in living standards, changes in the prevalence of (un)healthy behaviors, and advances in prevention and health care.[33,34]

In the United States, relative inequalities in mortality increased for both men and women between the 1990s and 2000s, but absolute inequalities in mortality increased mainly for US whites. Two possible explanations of why mortality of low educated Americans may have increased in recent times have been put forward; the widening of these educational differences may be the result of compositional changes in the low educated group, or it may reflect a causal process.[19] When taking into account the population size as well as the relative disadvantage experienced by educational groups in a measure of relative inequality (the relative index of inequality),[35] inequalities in the United States remained large. This finding suggests that these widening differences between educational groups in the US were not necessarily due to the more selected group of low educated Americans, and likely to be also the result of a causal process. A possible example of a causal process is the increasing need of higher education to obtain resources that improve health, such as employment, income or even marriage, resulting in low educated individuals being increasingly disadvantaged in obtaining these resources over time.[19]

Absolute and relative inequalities in mortality were larger in the US than in the European countries. The mortality increases observed among lower educated Americans were not observed in the European countries, suggesting this increase to be unique to the United States. Possible explanations for the more favorable trend in Europe include differences in social protection and health care systems, differences in the availability of dangerous prescription drugs, but also smaller inequalities in material circumstances and unhealthy behaviors. Findings from a recent study by Mackenbach and colleagues[27] showed that mortality increases among middle-aged Americans as reported by Case and Deaton[5] were not observed for Western European countries. They suggested that health care systems, part of the Welfare state that has been implemented in many European countries, may be able to constrain inequalities in mortality. However, the United States is lacking such a social structure.[27]

The US mortality increase was primarily driven by an increase in mortality from diseases other than cancer or cardiovascular disease. As many investments in health care including improvements to medical technologies have focused on cardiovascular disease and cancer, this finding indicates that the US mortality increase does not seem to be due to their health care system or differences in health care system between Europe and the US. Therefore, explanations that affect diseases other than cancer and cardiovascular disease deserve attention, such as the less generous US social protection system or cross-national differences in the stress associated with having a lower socioeconomic status. For Finnish men and women and Danish women, mortality from other diseases also increased slightly, but the increase was much larger for Americans than their Finnish or Danish counterparts. Recent studies showed that deaths of despair (or mortality from suicide, overdoses, and diseases related to drug or alcohol use) played an important role in the increased mid-life mortality of white Americans.[5] In this study, mortality was available in broader categories of causes of death and not by ICD code for the United States and the European countries. As we could not select the specific causes of death classified as deaths of despair, or more specifically the opioid epidemic, we unfortunately could not address either in a cross-national context. However, due to the nature of deaths of despair, these deaths would mainly be categorized as mortality from external causes and therefore not contribute to the US health disadvantage in terms of mortality from other diseases. When looking at changes in mortality from external causes over time, we observe mortality improvements for European men and women, but not for US whites. Nonetheless, the restricted sample size for the United States, the broader age interval (i.e. individuals aged 35 to 74 years, and thus not only middle-aged individuals), the included time period (i.e. increases due to the opioid crisis or deaths of despair started to profoundly increase only after 2000), and the broader categorization of causes of death prevented us from addressing the opioid epidemic or more generally deaths of despair from a cross-national perspective.

The observed mortality increases were higher for lower educated women than men in the US. The differences in absolute inequalities between the US and the European countries were also more pronounced for women than for men. A closer look at possible explanations for the increasing educational inequalities among US women is warranted. Montez and Zajacova[20] found that smoking-related causes of death were to some extent responsible for the widening mortality inequalities by education for US white women. In another study,[15] they found that economic circumstances and health behaviors, of which employment and smoking were most important, explained the growing gap in educational inequalities in mortality between 1997 and 2006. Female labor force participation was high in the US and Europe, but social protection policies were generally less comprehensive in the US than in Europe. Examples of policies, or the lack thereof, that may have contributed to the widening gap in the US, and subsequently a growing US health disadvantage, are childcare programs, availability of (paid) maternity leave, and employment protection and support programs.

Conclusions

To our knowledge, our study is the first to systematically compare educational inequalities in mortality in the US and Europe and show that an increase in mortality among lower educated women was unique to the United states and not observed in the included European countries. Our findings also suggest that this was not explained by changes in the educational distribution. The mortality increase among US whites was primarily driven by an increase in mortality from causes other than cancer, cardiovascular disease, or external causes. In contrast, mortality declines in the European countries have been shared more equally by the educational groups. This emphasizes the prospective benefits of policies focusing on the health of low educated individuals, such as employment protection programs, to tackle overall health disparities in the United States, but also consequently the US health disadvantage.

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SUPPLEMENTAL MATERIALS

TABLE A – **Overview of European and US data sets**

Country	Type of study	Baseline	Follow-up	Number of person-years	Number of deaths
1990s					
United States	National longitudinal mortality study for a representative sample of the population (NHIS)	1989–1991	1994–1996	887,152.8	6408.6
Belgium	National longitudinal mortality study	1991	1995	20,261,896	189,268
Denmark	National longitudinal mortality study	1991	1995	11,490,001	113,370.9
Italy (Turin)	Longitudinal mortality study for the city region	1991	1996	2,382,654	18,269
Finland	National longitudinal mortality study	1990	1995	12,056,248	102,395
Slovenia	National longitudinal mortality study	1991	1995	4,080,199	38,026.5
Sweden	National longitudinal mortality study	1990	1994	15,873,045	118,660
Switzerland	National longitudinal mortality study of Swiss nationals	1990	1995	12,815,842	92,221
2000s					
United States	National longitudinal mortality study for a representative sample of the population (NHIS)	1999–2001	2004–2006	686,160.5	4334.8
Belgium	National longitudinal mortality study	2001	2005	23,602,285	175,877
Denmark	National longitudinal mortality study	2001	2005	12,536,432	94,324.5
Italy (Turin)	Longitudinal mortality study for the city region	2001	2006	2,260,836	13,513
Finland	National longitudinal mortality study	2000	2005	13,142,294	91,185
Slovenia	National longitudinal mortality study	2002	2006	4,838,204	36,056.1
Sweden	National longitudinal mortality study	2000	2004	21,037,116	123,153
Switzerland	National longitudinal mortality study of Swiss nationals	2000	2005	13,327,745	68,024

Note. Due to weights, the number of person-years or the number of death values may not be a rounded number.

TABLE B – Overview of International Classification of Disease codes used for the causes of death for the United States and European countries

	ICD-10 coding	
Cause of death	United States	European countries
Mortality from cardiovascular disease[a]	I00–I99	I00–I99
Cancer mortality	C00–D48	C00–D48
Mortality from other diseases	All ICD codes except C00–D48, I00–I78, I80–I99, V01–Y36, and Y40–Y89.	All ICD codes between A00–U85 except C00–D48 and I00–I99.
Mortality from external causes	V01–Y36, Y40–Y89	V01–Y98
All-cause mortality	All abovementioned causes (A00–Y98)	All above mentioned causes (A00–Y98)

Note. [a] US coding excludes I79 (disorders of arteries, arterioles and capillaries in diseases classified elsewhere).

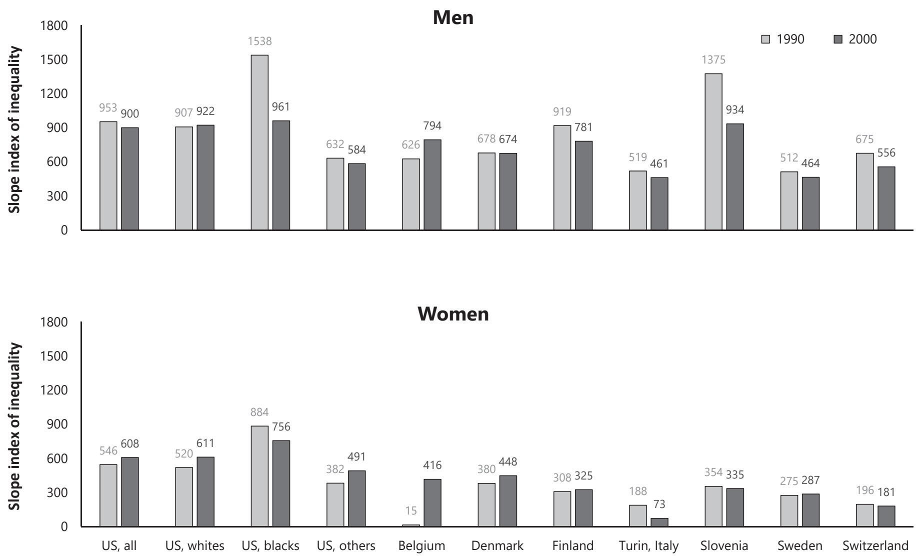

FIGURE A – Slope index of inequality for men and women aged 35 to 74 years in the United States (by race) and 6 European countries, early 1990s and 2000s.

Part two

Work-family factors and the US health disadvantage

Chapter 4

What's the difference? A gender perspective on understanding educational inequalities in all-cause and cause-specific mortality

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ABSTRACT

Objectives. Material and behavioral factors play an important role in explaining educational inequalities in mortality, but gender differences in these contributions have received little attention thus far. We examined the contribution of a range of possible mediators to relative educational inequalities in mortality for men and women separately.

Methods. Baseline data (1991) of men and women aged 25 to 74 years participating in the prospective Dutch GLOBE study were linked to almost 23 years of mortality follow-up from Dutch registry data (6099 men and 6935 women). Cox proportional hazard models were used to calculate hazard ratios with 95% confidence intervals, and to investigate the contribution of material (financial difficulties, housing tenure, health insurance), employment-related (type of employment, occupational class of the breadwinner), behavioral (alcohol consumption, smoking, leisure and sports physical activity, body mass index), and family-related factors (marital status, living arrangement, number of children) to educational inequalities in all-cause and cause-specific mortality, i.e. mortality from cancer, cardiovascular disease, other diseases and external causes.

Results. Educational gradients in mortality were found for both men and women. All factors together explained 62% of educational inequalities in mortality for lowest educated men, and 71% for lowest educated women. Yet, type of employment contributed substantially more to the explanation of educational inequalities in all-cause mortality for men (29%) than for women (−7%), whereas the breadwinner's occupational class contributed more for women (41%) than for men (7%). Material factors and employment-related factors contributed more to inequalities in mortality from cardiovascular disease for men than for women, but they explained more of the inequalities in cancer mortality for women than for men.

Conclusions. Gender differences in the contribution of employment-related factors to the explanation of educational inequalities in all-cause mortality were found, but not of material, behavioral or family-related factors. A full understanding of educational inequalities in mortality benefits from a gender perspective, particularly when considering employment-related factors.

INTRODUCTION

Higher levels of education are related to lower rates of all-cause and cause-specific mortality in most European countries including the Netherlands.[1–6] Prior studies highlighted the importance of material factors (e.g., income, type of health insurance, and financial difficulties) and behavioral factors (e.g., smoking, excessive alcohol consumption, and diet) in explaining educational inequalities in mortality.[7–12] Educational gradients in mortality have been found for both men and women.[4,5] Absolute mortality differences by education are generally larger for men than for women, but gender differences in relative mortality differences by education are less clear.[13,14] These findings suggest that explanations for the educational gradient may also differ for men and women, an issue that hardly received attention thus far.

Indeed, two mechanisms may explain why material and behavioral factors contribute differently to the explanation of educational inequalities in mortality between men and women. Firstly, the impact of education on material, employment-related, and behavioral factors may differ. For example, socioeconomic inequalities in overweight are smaller for Dutch men than for Dutch women,[15] and educational inequalities in smoking prevalence were larger for men than for women in the European Union.[16] Secondly, the effect of material, employment-related, and behavioral factors on mortality may differ. For example, unemployment is more strongly related to mortality for men than for women, which may be the result of employment status being more central to men's identities than to women's.[17]

In addition, family-related factors may play a role in generating gender differences in educational inequalities in mortality. The educational gradient in family factors may be different for men and women. Indeed, higher educated men and women are more likely to ever get married than their lower educated counterparts, but this marriage gap seems to be larger for men than for women.[18,19] Additionally, higher educated Dutch women are more likely to remain childless than low educated women, whereas the proportion of Dutch men that remains childless is similar across different educational levels.[19] Additionally, mortality differentials by marital status, living arrangement, and parenthood status have been found; mortality is lower for married individuals, individuals living with a partner, or parents, than for their unmarried, living alone, and childless counterparts, respectively.[20–22] These family factors may also differentially impact mortality of men and women. For example, marriage is more protective of health and mortality for men than for women.[23] There seem to be no clear gender differences in the association between parenthood and mortality.[24,25] To our knowledge the contribution of these factors to educational inequalities in mortality has not yet been studied.

A proper understanding of the underlying causes of inequalities in mortality is needed for adequate interventions and policies aimed at bridging the health gap between the higher and lower educated. Perhaps surprisingly, and despite good reasons to assume that the explanation of socioeconomic inequalities in health may differ by gender, only few studies investigated this with a specific gender perspective.[26–29] The aim of this article was to examine whether explanations for relative educational inequalities in mortality differed between men and women. We examined multiple material, employment-related, behavioral, and family-related factors, using data from a Dutch cohort study linked on an individual level to registry data with almost 23 years of mortality follow-up.

METHODS

Data came from the prospective GLOBE study (the Dutch acronym for Health and Living Conditions of the Population of Eindhoven and surroundings)[30] initiated to quantitatively assess mechanisms and factors explaining socioeconomic inequalities in health in the Netherlands.[31] Baseline information was collected through a postal survey in 1991. This survey was distributed among 27,070 non-institutionalized respondents aged 15 to 74 years living in Eindhoven, a city in the South of the Netherlands, and its surrounding municipalities.[32] The response for this postal survey was 70.1%, leaving 18,973 respondents in the baseline sample. This sample was then on an individual level linked (94%) to almost 23 years of mortality follow-up from Statistics Netherlands.

Men and women aged 25 to 74 years were included in our study (n=15,534). We excluded those who reported at least one of six severe chronic diseases (chronic obstructive pulmonary disease, heart disease, stroke, renal disease, diabetes or cancer) at baseline (n=2500). Having a chronic illness may influence an individual's survival, but it may also affect their explanatory factors such as health behaviors. For example, individuals may improve their health behaviors after a health scare due to chronic illness, e.g., cease smoking, eat healthier or become more physically active. However, our explanatory variables may also have influenced the likelihood of becoming chronically ill, as unhealthy behaviors increase the chance of becoming chronically ill.[33] As no information was available prior to our baseline data in 1991, we cannot disentangle how these two mechanisms might be working together due to lack of a time dimension. Overall, our analyses included 6099 men and 6935 women.

Levels of education

Educational level was used to represent the socioeconomic position of the individual, as it is commonly used as an indicator for socioeconomic status in the Netherlands. We distinguished 4 levels of educational attainment with the following equivalent levels of the International Standard Classification of Education (ISCED):[34] primary education only ("lowest", ISCED 0 and 1), lower vocational school and lower secondary school ("low", ISCED 2), intermediate vocational school and intermediate or higher secondary school ("mid", ISCED 3 and 4), and higher vocational school and university ("high", ISCED 5 and 6).

Explanatory variables: Material, employment-related, behavioral, and family-related factors

All explanatory factors were derived from the postal survey collected in 1991. Financial problems, housing tenure, and health insurance were included as material factors. Financial problems were measured by asking the respondents if they had any difficulties paying bills, food, rent, electricity, etcetera during the previous year (no difficulties, some difficulties, and big difficulties). With regards to housing tenure, we distinguished between individuals owning and those renting their home. The two possible types of health insurance were public and private insurance. As employment-related factors, we included the respondent's employment status (employed, unemployed, retired, others, e.g., students or homemakers) and the occupation of the main breadwinner (professional, white collar, blue collar occupations, not in the workforce).[35]

The behavioral factors included in this study were alcohol consumption, smoking, physical activity in leisure time, physical activity in sports, and body mass index (BMI). Alcohol consumption (weekly number of drinks) was calculated from information on the number of days per week the respondent drank alcoholic drinks and the number of alcoholic drinks (units) consumed on such a day; no consumption, light consumption (1 to 14 drinks for men, 1 to 7 drinks for women), moderate consumption (15 to 21 drinks for men, 8 to 14 drinks for women), and heavy consumption (22 or more drinks for men, 15 or more drinks for women; same cut-off as used by Statistics Netherlands to define excess alcohol consumption). Regarding smoking status, we distinguished current smokers from former smokers and never smokers. Physical activity in leisure time was measured by two questions "How many hours of your leisure time do you spend in total per week on working in the garden, biking, walking, walking the dog?" and "How many hours of your leisure time do you spend in total per week on chores, fixing the house, repairs?". Sports physical activity was measured by the question "Do you exercise?". Both physical activity questions had the following 4 answer categories; (i) no, (almost) never ("inactive"), (ii) yes, less than 1 hour a week ("little active"), (iii) yes, approximately 1 to 2 hours a week ("moderately active"), and (iv) yes, 2 hours a week or more ("active"). BMI (kg/m^2) was calculated from self-reported weight and height (underweight, BMI<20; normal weight, 20≤BMI<25; overweight, 25≤BMI≤30; or obese, BMI>30). BMI was included here as it is mainly determined by behavior.

As family-related factors we included marital status, living arrangement, and number of children. Marital status was categorized into currently married, previously married (i.e., divorced and widowed), and never married. We also included living arrangement (living together with a partner or living alone). Lastly, we distinguished between no, one, two, and three or more children.

Outcome measures

Mortality data were obtained from Statistics Netherlands. The GLOBE baseline survey (April 1, 1991) was linked to death registry data until December 31, 2013, allowing for almost 23 years of mortality follow-up. We examined educational inequalities in all-cause mortality, as well as in 4 categories of causes of death: mortality from cancer, cardiovascular disease (CVD), other diseases, and external causes. The International Classification of Disease, 10th revision codes[36] for the causes of death included in each of these categories are provided in the footnote of Table 4.

Analysis

Missing values for the explanatory factors, but not educational attainment or mortality, were handled by applying multiple imputations (M=5).[37,38] We imputed missing values based on all other factors included in the analysis.

Our analytical strategy consisted of four steps, and essentially follows the steps of a mediation analysis.[39] We thus assume causal effects of education on mortality, of education on the mediators, and of the mediators on mortality, as would be done within a mediation analysis. However, we understand that our observational study cannot lead to causal effects, and therefore we refer to our results as associations. First, we calculated hazard ratios (HR) and their 95% confidence intervals (CI) for the association between educational level and mortality for men and women, using Cox proportional hazard models with age as the time scale (also referred to as model 0). Second, age-standardized prevalence rates of the explanatory factors by educational level were calculated for men and women. Third, Cox proportional hazard models were used to assess the association between each explanatory factor and mortality, adjusted for education (added as an independent variable to the models). Fourth, we estimated hazard ratios for education after inclusion of the material, employment-related, behavioral and/or family-related factors in Cox proportional hazard models. The contributions of these factors to educational inequalities in mortality were then estimated based on the changes in the hazard ratios for education after inclusion of these explanatory factors (adjusted models). The absolute change in the hazard ratios (HR) for education after the explanatory factors were included, was calculated by $HR_{model\,0} - HR_{adjusted}$. The relative change was calculated as follows: $(HR_{model\,0} - HR_{adjusted})/(HR_{model\,0} - 1)$. We estimated the contributions of each explanatory factor to educational inequalities in mortality separately and for the broader categories of factors. Confidence intervals of the contributions to educational inequalities in mortality were calculated using a bootstrap with 5000 repetitions; 1000 repetitions per imputed dataset. The same procedure was used to assess the contributions of the explanatory factors to educational inequalities in cause-specific mortality. Cause-specific mortality was analyzed within a competing risks framework;[40] as we were interested in mortality from a specific cause and wanted to account for the fact that individuals may die from other causes than the one we were interested in. Gender differences in the contribution of material, employment, behavioral, and family factors to the explanation of educational inequalities in all-cause and cause-specific mortality were assessed by comparing the estimated 95% confidence intervals of men and women. Gender differences were determined based on non-overlapping confidence intervals of the contribution of factors to educational inequalities in mortality for men and women.

The Cox proportional hazard models and the multiple imputation strategy were performed using Stata SE version 14.1. The bootstrapped confidence intervals were calculated in R version 3.3.1.

RESULTS

As compared to those with the highest levels of education, significantly increased hazard ratios were found for those with lower levels of education (Figure 1). Whereas an inverse educational gradient in mortality was found for men, reasonably similar hazard ratios were found at all three lower levels of education for women. Proportions of men and women in each educational category, with their 95% confidence intervals, are presented in Table A of the supplemental materials.

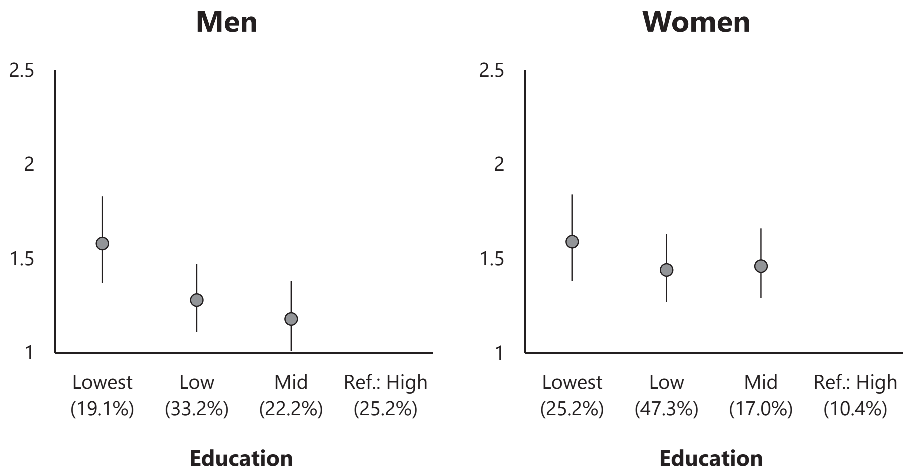

FIGURE 1 – **Mortality hazard ratios by education for men and women**
Notes. Ref.: Reference category. The analysis was controlled for age. Proportions of men and women aged 25 to 74 years in each educational category are shown in brackets.

Distribution of explanatory factors by educational level

Inverse educational gradients were found for all material and employment-related factors, but noticeable differences were found in the size of these gradients between men and women

(Table 1). The educational gradient was larger for men than women with regards to the proportion privately insured, unemployed, and blue-collar occupation of the breadwinner.

Educational gradients were also found for the behavioral factors, with sometimes contrasting directions between men and women. Specifically, the educational gradient for not consuming any alcohol was weaker for men than for women. Whereas heavy alcohol consumption decreased with increasing educational levels for men, it increased with education for women. The observed gradient in current smoking by educational level was smaller for men than for women, but in the same direction. The proportion of men being moderately active in leisure activities increased with higher levels of education, but the proportion of women being moderately active was similar across educational levels. The educational gradient in being active in leisure activities was similar across educational levels for men, but increased with increasing educational levels for women. The observed educational gradient in being active in sports activities was in the same direction for men and women, although smaller for men than for women.

Educational gradients were least clear for the family-related factors. The proportion of currently married persons was lowest among low educated men and among high educated women. Living alone was less common for men with higher education than those with lower education, but for women it was slightly higher for those with higher levels of education. With increasing levels of education, childlessness slightly decreased for men, but increased for women.

Explanatory factors and their association with mortality

The associations of all material factors with mortality had comparable magnitudes for both men and women (Table 2). For the employment-related factors, some gender differences were found. Unemployment was associated with higher mortality for men (hazard ratio [HR]=1.84, 95% confidence interval [CI]: 1.58, 2.14), but not for women (HR=1.26, 95% CI: 0.90, 1.64). In contrast, blue-collar occupation of the breadwinner was not associated with higher mortality for men (HR=1.03, 95% CI: 0.89, 1.19), but it was associated with higher mortality for women (HR=1.31, 95% CI: 1.13, 1.52). Being a former smoker, being previously married, and living alone was more strongly associated with mortality for men (former smoker vs. never smoker: HR=1.33, 95% CI: 1.09, 1.62; previously married vs. currently married: HR=1.55, 95% CI: 1.33, 1.79; and living alone vs. living with a partner: HR=1.55, 95% CI: 1.35, 1.77) than for women (HR=0.96, 95% CI: 0.84, 1.09; HR=1.18, 95% CI: 1.05, 1.33; and HR=1.21, 95% CI: 1.08, 1.35; respectively).

Contribution to educational inequalities in all-cause mortality

A statistically significant elevated mortality risk for the lowest educated men and women (HR=1.58, 95% CI: 1.37, 1.83 for men; HR=1.59, 95% CI: 1.25, 2.02 for women; Table 3) was substantially attenuated after accounting for material factors (67% for men, 51% for women),

TABLE 1 – Educational gradients (percentages) in explanatory factors for men and women

	Men				Women				Testing for a gender difference in gradient (*p* value) [a]
	Lowest	Low	Mid	High	Lowest	Low	Mid	High	
Material factors									
Financial difficulties									
No	65.1	76.2	83.0	92.6	62.9	78.8	83.6	90.0	0.325
Some	27.4	21.3	14.8	6.5	29.5	17.7	13.8	9.0	0.430
Big	7.6	2.6	2.1	0.9	7.6	3.5	2.7	1.0	0.303
Housing tenure									
Owned home	29.5	48.4	62.0	76.5	34.2	53.0	67.3	74.2	0.112
Rented home	70.5	51.6	38.0	23.5	65.8	47.0	32.7	25.8	"
Health insurance									
Private	7.8	27.0	50.6	79.0	15.9	31.2	48.3	66.6	<0.001
Public	92.2	73.0	49.4	21.0	84.1	68.8	51.7	33.4	"
Employment-related factors									
Employment									
Employed	46.7	60.2	61.0	66.1	18.9	24.4	34.0	41.0	0.932
Unemployed	27.6	12.7	9.6	4.6	9.7	6.4	4.9	7.1	<0.001
Retired	25.1	26.3	27.9	28.4	6.9	7.2	10.0	15.8	0.065
Other	0.5	0.8	1.6	1.0	64.4	62.0	51.1	36.1	<0.001
Occupation of the breadwinner									
Professional	4.2	16.8	44.0	85.3	10.9	25.5	49.6	77.4	<0.001
White collar	15.0	23.7	26.9	8.5	14.2	22.3	22.2	11.7	0.001
Blue collar	78.4	57.9	27.0	4.9	52.4	38.1	18.9	5.6	<0.001
Not in the workforce	2.5	1.6	2.2	1.3	22.6	14.2	9.2	5.3	0.001
Behavioral factors									
Alcohol consumption									
No	20.0	13.0	10.9	6.7	44.9	31.5	21.2	17.2	0.005
Light	54.9	61.2	62.7	67.6	38.5	47.8	48.6	51.7	0.618
Moderate	8.5	11.4	12.8	15.1	11.5	13.5	18.6	20.9	0.147
Heavy	16.7	14.4	13.7	10.5	5.1	7.3	11.5	10.2	<0.001
Body mass index (BMI)									
Underweight	4.3	3.4	3.4	4.0	7.2	8.5	10.1	12.1	0.071
Normal weight	46.2	46.9	55.1	61.8	49.1	56.2	62.1	65.0	0.844
Overweight	41.8	44.6	37.5	32.4	32.3	28.5	23.5	17.7	0.118
Obese	7.6	5.1	4.0	1.8	11.4	6.7	4.3	5.2	0.989
Smoking									
Current	54.8	45.2	38.2	35.4	42.1	32.7	28.9	19.9	0.009
Former	34.1	40.4	43.5	42.9	21.7	28.2	30.7	32.5	0.181

TABLE 1 – **Educational gradients (percentages) in explanatory factors for men and women (continued)**

	Men				Women				Testing for a gender difference in gradient (*p* value) [a]
	Lowest	Low	Mid	High	Lowest	Low	Mid	High	
Never	11.1	14.5	18.3	21.7	36.2	39.1	40.4	47.7	0.056
Leisure activity									
Inactive	15.5	11.9	12.2	10.1	18.6	11.7	10.8	7.2	0.003
Little	12.9	14.0	14.4	16.3	16.8	16.6	15.3	18.4	0.119
Moderate	22.5	25.1	26.0	28.1	29.7	27.5	29.9	26.7	0.005
Active	49.1	49.0	47.5	45.5	34.9	44.3	44.0	47.7	<0.001
Sports activity									
Inactive	73.3	60.9	51.6	44.0	72.9	56.9	46.2	43.1	0.320
Little	4.8	6.6	9.4	8.4	7.2	8.0	8.7	11.3	0.391
Moderate	9.9	14.3	16.6	23.8	12.4	21.5	26.9	23.3	0.302
Active	12.0	18.2	22.4	23.8	7.4	13.6	18.2	22.3	0.004
Family-related factors									
Marital status									
Currently married	73.6	82.1	81.1	77.7	71.5	78.0	72.0	65.9	0.001
Previously married	10.2	7.5	7.5	8.7	20.4	15.4	14.3	11.2	0.025
Never married	16.2	10.4	11.4	13.6	8.2	6.6	13.7	22.9	<0.001
Living arrangement									
Living with partner	78.0	86.9	86.4	84.2	75.7	81.5	76.7	73.0	0.001
Living alone	22.0	13.1	13.6	15.8	24.3	18.5	23.3	27.0	"
Number of children									
0	26.0	18.8	22.3	22.0	12.2	15.2	21.8	32.1	<0.001
1	16.6	14.0	12.2	7.3	14.4	12.7	10.8	6.9	0.275
2	32.7	38.5	37.5	35.4	42.3	38.5	31.5	29.0	<0.001
3 or more	24.6	28.7	28.1	35.3	31.0	33.6	35.9	32.0	0.015

Notes. Age-standardized towards the age distribution of men and women observed in the data. The imputed values resulting from our multiple imputations strategy were also included in these distributions. [a] The *p* value of the difference in the educational gradient for men and women came from interaction models (education × gender) in which we additionally controlled for age and age × gender interactions.

and it was no longer statistically significantly higher among men (HR=1.18, 95% CI: 0.99, 1.40 for men; HR=1.29, 95% CI: 1.00, 1.66 for women). Type of health insurance seemed to explain more of the excess mortality risk of the lowest educated men (53%) than of the lowest educated women (32%). Both employment-related factors together explained a similar share of the educational inequalities for both men (between 21 and 28%) and women (between 11 and 34%), but strong differences were found for the separate employment-

TABLE 2 – **Bivariate associations between the explanatory factors and mortality for men and women**

	Men		Women		Testing for a gender difference in the bivariate associations (*p* value)[a]
	HR	(95% CI)	HR	(95% CI)	
Material factors					
Financial difficulties					
No	1	Ref.	1	Ref.	
Some	1.16	(1.02, 1.32)	1.28	(1.13, 1.46)	0.278
Big	1.41	(1.06, 1.87)	1.45	(1.13, 1.88)	0.977
Housing tenure					
Owned home	1	Ref.	1	Ref.	
Rented home	1.28	(1.15, 1.43)	1.29	(1.16, 1.44)	0.711
Health insurance					
Private	1	Ref.	1	Ref.	
Public	1.34	(1.18, 1.51)	1.25	(1.11, 1.40)	0.358
Employment-related factors					
Employment					
Employed	1	Ref.	1	Ref.	
Unemployed	1.84	(1.58, 2.14)	1.26	(0.97, 1.64)	0.012
Retired	1.10	(0.95, 1.26)	0.90	(0.71, 1.12)	0.313
Other	0.92	(0.47, 1.81)	0.86	(0.71, 1.05)	0.979
Occupation of the breadwinner					
Professional	1	Ref.	1	Ref.	
White collar	1.07	(0.91, 1.25)	1.17	(0.99, 1.38)	0.384
Blue collar	1.03	(0.89, 1.19)	1.31	(1.13, 1.52)	0.026
Not in the workforce	1.27	(0.87, 1.85)	1.22	(1.04, 1.44)	0.936
Behavioral factors					
Alcohol consumption					
No	1.20	(1.04, 1.38)	1.14	(1.01, 1.28)	0.617
Light	1	Ref.	1	Ref.	
Moderate	1.12	(0.94, 1.32)	1.11	(0.93, 1.32)	0.967
Heavy	1.71	(1.48, 1.98)	1.60	(1.30, 1.96)	0.527
Body mass index (BMI)					
Underweight	1.58	(1.20, 2.07)	1.57	(1.26, 1.96)	0.943
Normal weight	1	Ref.	1	Ref.	
Overweight	1.04	(0.94, 1.16)	1.04	(0.92, 1.18)	0.948
Obese	1.36	(1.07, 1.74)	1.32	(1.11, 1.58)	0.792
Smoking					
Current	2.49	(2.05, 3.02)	2.06	(1.83, 2.33)	0.053
Former	1.33	(1.09, 1.62)	0.96	(0.84, 1.09)	0.008

TABLE 2 – **Bivariate associations between the explanatory factors and mortality for men and women (continued)**

	Men		Women		Testing for a gender difference in the bivariate associations (*p* value)[a]
	HR	(95% CI)	HR	(95% CI)	
Never	1	Ref.	1	Ref.	
Leisure activity					
Inactive	1.43	(1.21, 1.69)	1.50	(1.29, 1.75)	0.607
Little	1.28	(1.10, 1.50)	1.15	(0.99, 1.33)	0.410
Moderate	1.04	(0.92, 1.17)	1.03	(0.90, 1.17)	0.930
Active	1	Ref.	1	Ref.	
Sports activity					
Inactive	1.26	(1.09, 1.46)	1.41	(1.18, 1.69)	0.317
Little	1.12	(0.89, 1.43)	1.15	(0.90, 1.47)	0.856
Moderate	0.96	(0.78, 1.18)	1.09	(0.88, 1.35)	0.377
Active	1	Ref.	1	Ref.	
Family-related factors					
Marital status					
Currently married	1	Ref.	1	Ref.	
Previously married	1.55	(1.33, 1.79)	1.18	(1.05, 1.33)	0.008
Never married	1.55	(1.27, 1.90)	1.31	(1.09, 1.58)	0.300
Living arrangement					
Living with partner	1	Ref.	1	Ref.	
Living alone	1.55	(1.35, 1.77)	1.21	(1.08, 1.35)	0.008
Number of children					
0	1.10	(0.94, 1.28)	1.23	(1.04, 1.44)	0.288
1	1.01	(0.85, 1.19)	1.20	(1.01, 1.43)	0.128
2	1	Ref.	1	Ref.	
3 or more	0.97	(0.86, 1.09)	0.92	(0.81, 1.04)	0.663

Notes. HR: hazard ratios; CI: confidence interval; Ref: reference category. Mortality hazard ratios of the explanatory variable when controlling for education only. As the Cox regression models included age as timescale, it was unnecessary to also include age as a covariate in the models. [a] A possible differential association of these explanatory factors with mortality for men and women was determined by adding an interaction term between the explanatory factor and gender, and testing its statistical significance (*p* value).

related factors. Type of employment (and specifically unemployment) explained more of the educational inequalities for men (29%) than for women (–7%), whereas occupation of the breadwinner seemed to explain more for women (41%) than for men (7%). Behavioral factors explained a similar proportion of the educational inequalities for men (between 11 and 36%) and women (between 13 and 37%). Family-related factors did not explain educational inequalities for either men or women; they even seemed to slightly strengthen

TABLE 3 – **Contributions of the explanatory factors to educational inequalities in all-cause mortality for lowest educated men and women**

	Men						Women					
	Level of education			Change in educational inequality			Level of education			Change in educational inequality		
	Lowest		High	Absolute decline[a]	Percentage decline[a]		Lowest		High	Absolute decline[a]	Percentage decline[a]	
Models	HR	(95% CI)	Ref.		%	(95% CI)[b]	HR	(95% CI)	Ref.		%	(95% CI)[b]
0. No additional controls	1.58	(1.37, 1.83)	1				1.59	(1.25, 2.02)	1			
1. Material	1.18	(0.99, 1.40)	1	0.40	67%	(46%, 103%)	1.29	(1.00, 1.66)	1	0.30	51%	(29%, 93%)
Financial difficulties	1.51	(1.30, 1.75)	1	0.07	12%	(4%, 24%)	1.49	(1.17, 1.90)	1	0.10	17%	(9%, 34%)
Housing tenure	1.40	(1.20, 1.63)	1	0.18	31%	(18%, 49%)	1.41	(1.10, 1.81)	1	0.18	31%	(15%, 56%)
Health insurance	1.27	(1.07, 1.51)	1	0.31	53%	(31%, 81%)	1.40	(1.09, 1.80)	1	0.19	32%	(15%, 61%)
2. Employment-related	1.42	(1.18, 1.71)	1	0.16	28%	(3%, 58%)	1.39	(1.07, 1.81)	1	0.20	34%	(2%, 55%)
Employment	1.41	(1.21, 1.63)	1	0.17	29%	(20%, 45%)	1.63	(1.27, 2.08)	1	−0.04	−7%	(−22%, 2%)
Occ. of the breadwinner[c]	1.54	(1.28, 1.85)	1	0.04	7%	(−20%, 37%)	1.35	(1.04, 1.75)	1	0.24	41%	(8%, 59%)
3. Behavioral factors	1.39	(1.20, 1.62)	1	0.19	33%	(16%, 50%)	1.37	(1.06, 1.75)	1	0.22	37%	(15%, 77%)
Alcohol consumption	1.55	(1.34, 1.79)	1	0.03	5%	(−3, 14%)	1.61	(1.26, 2.06)	1	−0.02	−3%	(−20%, 10%)
BMI	1.55	(1.34, 1.79)	1	0.03	5%	(1%, 11%)	1.57	(1.23, 2.00)	1	0.02	3%	(−5%, 12%)
Smoking	1.50	(1.30, 1.73)	1	0.08	14%	(3%, 26%)	1.48	(1.16, 1.89)	1	0.11	19%	(4%, 41%)
Leisure activity	1.59	(1.38, 1.84)	1	−0.01	−2%	(−7%, 4%)	1.53	(1.20, 1.95)	1	0.06	10%	(1%, 22%)
Sports activity	1.49	(1.29, 1.72)	1	0.09	16%	(9%, 27%)	1.49	(1.17, 1.90)	1	0.10	17%	(8%, 34%)
4. Family-related factors	1.57	(1.36, 1.81)	1	0.01	2%	(−7%, 11%)	1.62	(1.27, 2.07)	1	−0.03	−5%	(−25%, 6%)
Marital status	1.57	(1.36, 1.81)	1	0.01	2%	(−4%, 10%)	1.61	(1.26, 2.06)	1	−0.02	−3%	(−22%, 6%)
Living arrangement	1.56	(1.35, 1.81)	1	0.02	3%	(−3%, 9%)	1.58	(1.24, 2.01)	1	0.01	2%	(−3%, 6%)
Number of children	1.56	(1.35, 1.81)	1	0.02	3%	(−2%, 10%)	1.65	(1.29, 2.10)	1	−0.06	−10%	(−26%, −1%)
5. All factors	1.22	(1.00, 1.49)	1	0.36	62%	(30%, 101%)	1.17	(0.89, 1.54)	1	0.42	71%	(28%, 123%)

Notes. HR: mortality hazard ratios; CI: confidence interval; Ref: reference category. [a] Negative absolute and percentage declines indicate an increase in the educational inequality. [b] Confidence intervals (CIs) of the percentage decline were calculated using bootstraps with 5000 repetitions; 1000 repetitions per imputed dataset. [c] Occ.: Occupation.

TABLE 4 – **Contributions of the explanatory factors to educational inequalities in cause-specific mortality for lowest educated men and women**

	Men					Women				
	Level of education			Change in educational inequality		Level of education			Change in educational inequality	
	Lowest		High	Absolute	Percentage	Lowest		High	Absolute	Percentage
Models	HR	(95% CI)	Ref.	decline[a]	decline[a]	HR	(95% CI)	Ref.	decline[a]	decline[a]
Mortality from cardiovascular disease[b]										
0. No additional controls	1.58	(1.23, 2.04)	1			2.08	(1.26, 3.44)	1		
1. Material	1.25	(0.91, 1.71)	1	0.33	57%	2.13	(1.27, 3.57)	1	–0.05	–5%
2. Employment-related	1.17	(0.84, 1.62)	1	0.41	71%	1.90	(1.11, 3.24)	1	0.18	17%
3. Behavioral	1.39	(1.06, 1.81)	1	0.19	33%	1.87	(1.11, 3.16)	1	0.21	19%
4. Family-related	1.57	(1.21, 2.03)	1	0.01	2%	2.02	(1.22, 3.32)	1	0.06	6%
5. All factors	1.07	(0.75, 1.52)	1	0.51	88%	1.95	(1.11, 3.41)	1	0.13	12%
Cancer mortality[c]										
0. No additional controls	1.50	(1.20, 1.89)	1			1.33	(0.91, 1.95)	1		
1. Material	1.26	(0.96, 1.66)	1	0.24	48%	1.04	(0.70, 1.55)	1	0.29	88%
2. Employment-related	1.52	(1.14, 2.04)	1	–0.02	–4%	1.14	(0.75, 1.73)	1	0.19	58%
3. Behavioral	1.33	(1.05, 1.69)	1	0.17	34%	1.21	(0.82, 1.79)	1	0.12	36%
4. Family-related	1.50	(1.19, 1.88)	1	0.00	0%	1.38	(0.94, 2.04)	1	–0.05	–15%
5. All factors	1.36	(1.00, 1.86)	1	0.14	28%	0.96	(0.61, 1.49)	1	0.37	112%
Mortality from other diseases[d]										
0. No additional controls	1.31	(0.99, 1.74)	1			1.43	(0.94, 2.19)	1		
1. Material	1.02	(0.73, 1.43)	1	0.29	94%	1.18	(0.77, 1.82)	1	0.25	58%
2. Employment-related	1.27	(0.89, 1.81)	1	0.04	13%	1.30	(0.83, 2.05)	1	0.13	30%
3. Behavioral	1.13	(0.83, 1.53)	1	0.18	58%	1.16	(0.75, 1.80)	1	0.27	63%
4. Family-related	1.28	(0.96, 1.71)	1	0.03	10%	1.48	(0.96, 2.27)	1	–0.05	–12%

TABLE 4 – **Contributions of the explanatory factors to educational inequalities in cause-specific mortality for lowest educated men and women (continued)**

	Men					Women				
	Level of education			Change in educational inequality		Level of education			Change in educational inequality	
	Lowest		High	Absolute	Percentage	Lowest		High	Absolute	Percentage
Models	HR	(95% CI)	Ref.	decline[a]	decline[a]	HR	(95% CI)	Ref.	decline[a]	decline[a]
5. All factors	1.03	(0.70, 1.51)	1	0.28	90%	1.06	(0.66, 1.72)	1	0.37	86%
Mortality from external causes[e]										
0. No additional controls	0.95	(0.39, 2.32)	1			2.05	(0.48, 8.77)	1		
1. Material	1.17	(0.38, 3.63)	1	−0.22	−440%	1.66	(0.35, 8.00)	1	0.39	37%
2. Employment-related	1.21	(0.32, 4.54)	1	−0.26	−520%	1.27	(0.30, 5.45)	1	0.78	74%
3. Behavioral	1.04	(0.41, 2.61)	1	−0.09	−180%	2.27	(0.51, 10.04)	1	−0.22	−21%
4. Family-related	0.98	(0.39, 2.44)	1	−0.03	−60%	2.20	(0.50, 9.65)	1	−0.15	−14%
5. All factors	1.42	(0.37, 5.42)	1	−0.47	−940%	1.52	(0.28, 8.22)	1	0.53	50%

Notes. HR: mortality hazard ratios; CI: confidence interval; Ref: reference category. [a] Negative absolute and percentage declines indicate an increase in the educational inequality. [b] Mortality from cardiovascular disease includes deaths with International Classification of Diseases (ICD)[36] codes between I00 and I99. [c] Cancer mortality includes deaths with ICD codes between C00 and D48. [d] Mortality from other diseases includes deaths with all other ICD codes than those included in cardiovascular disease, cancer or external causes. [e] Mortality from external causes includes deaths with ICD codes between V01 and Y89.

the inequalities for both. When all risk factors were considered, a substantial part of the educational inequalities in mortality was explained for both men (between 33 and 62%) and women (between 28 and 71%). The increased HR of the lowest educated men compared to the highest educated men remained borderline statistically significant (HR=1.22, 95% CI: 1.00, 1.49). Results for low and mid educated men and women are presented in Tables B and C of the supplemental materials.

Explaining educational inequalities in cause-specific mortality

All categories of explanatory variables seemed to explain more of the educational inequalities observed in cardiovascular mortality for men (88%, Table 4) than for women (12%). For women, educational inequalities in mortality from cardiovascular disease (HR=2.08, 95% CI: 1.26, 3.44) were stronger than those in all-cause mortality (HR=1.59, 95% CI: 1.25, 2.02), and they persisted even after controlling for all explanatory factors (HR=1.95, 95% CI: 1.11, 3.41). For men, the risk factors explained less of the educational inequalities in cancer mortality (28%) than of the educational inequalities in all-cause mortality (62%). All explanatory variables, with the exception of family-related factors, appeared to explain more of the educational inequalities in cancer mortality for women (112%) than for men (28%). With regards to mortality from other diseases, material and family-related factors seemed to explain a larger part of the educational inequalities for men (94% and 10% respectively) than for women (58% and −12% respectively), whereas employment-related and behavioral factors seemed to explain more for women (30% and 63% respectively) than for men (13% and 58% respectively). Our explanatory variables explained some of the elevated mortality risk from external causes for lowest educated women with respect to higher educated women (50%), but they did not contribute to an explanation for men.

DISCUSSION

Educational gradients in mortality were found for both men and women. Although a substantial and reasonably similar part of the educational inequalities in mortality was explained by all material, employment-related, behavioral, and family-related factors together for both men (62%) and women (71%), the specific contributions of some factors differed between men and women. Specifically, type of employment explained more of the educational inequalities in all-cause mortality for men than for women, whereas the occupational class of the breadwinner explained more for women than for men. Our results also suggested that material and employment-related factors contribute more to inequalities in mortality from cardiovascular disease for men than for women, but they explained more of the inequalities in cancer mortality for women than for men.

Methodological considerations

Besides a mortality follow-up of more than 20 years, a major strength of this study is the inclusion of a broad selection of material, employment-related, behavioral, and family-related factors. However, these factors were self-reported and may contain measurement error. If biases in self-reports differed by education or gender, for which evidence exists, this may have affected our results. For example, in the French GAZEL study, men underestimated their weight and overestimated their height less than women, and high educated men and women overestimated their height less than their low educated counterparts.[41] Differences in self-reporting biases by gender or education have also been found for other (behavioral) factors, including physical activity[42] and smoking.[43] Yet, the exact direction of self-report misclassification by gender and socioeconomic status is less clear.

In this study, we examined the contribution of single measurements of material, employment, behavioral, and family factors to educational inequalities in mortality. It may be argued that using multiple measurements of the explanatory variables would be better as it allows to account for possible changes over time in inequalities in these variables. Recent studies have shown that the contribution of behavioral factors to socioeconomic inequalities in mortality was (slightly) larger when multiple measurements over time of these factors were included.[44–46] Using the same GLOBE data, Oude Groeniger and colleagues also found a larger contribution of behavioral factors to educational inequalities in mortality when multiple measurements were used, but a smaller contribution of material factors.[47] Yet, another study found a slightly higher attenuation of educational inequalities in mortality for men when behavioral, psychosocial, biomedical risk factors, and employment were measured twice (63%, compared to 53% when only the baseline measurement was used), but no change in the attenuation for women.[48] We believe our overall conclusions to be valid, as by using only a single measurement we may have slightly underestimated the contribution of behavioral factors and slightly overestimated the contribution of material factors to socioeconomic inequalities in mortality.

Longitudinal data on the explanatory variables were available but only for two subsamples of the GLOBE study (n=5667). After exclusion of the chronically ill and respondents with missing information on any of the other variables, the final sample would be even smaller. As our main focus was on estimating gender differences in the explanations of educational inequalities in mortality, we decided to use the baseline sample. We believe that misclassification bias due to changes in educational status during the 23 years of follow-up is relatively small as our sample exists of individuals aged 25 years and over, who are likely to have finished their education. Second, using the longitudinal data from the GLOBE study, Oude Groeniger and colleagues found that although the contribution of behavioral and material factors to explaining educational inequalities in mortality changed when these factors were measured multiple times, they did not observe clear gender differences in these changes.[47] Based on these findings, we therefore do not believe that differential changes in the explanatory factors by gender would contribute to explaining the observed differences.

Despite the fact that we used a broad set of material, employment-related, behavioral, and family-related factors in our study, it may be argued that inclusion of more specific explanatory factors should be considered. To the extent that the prevalence of such specific measures and their association with mortality differs between men and women, including them could have led to more specific estimations of the contribution of the explanatory factors. For example, dietary intake, e.g., fruit and vegetable consumption, is educationally patterned,[49] and may play a more important role in explaining educational inequalities in mortality than a summary measure such as BMI. Unfortunately our data did not allow us to include these more specific measures, but we strongly encourage future studies to consider these factors and examine their contribution to explaining educational inequalities in mortality.

Finally, although the study population of the GLOBE study is reasonably representative for the Dutch ethnic population, residents of non-Western ethnicities were almost absent in the baseline measurement.[31] Generalizing our findings to other populations or countries should therefore be done with caution.

Interpretation

Overall, we found a similar contribution of material and behavioral factors to socioeconomic inequalities in all-cause mortality for both men and women. Of all explanatory variables, material factors contributed most to the explanation of educational inequalities in mortality. This finding is in line with previous research.[7,8,10] Behavioral factors also provided a substantial contribution to educational inequalities in all-cause mortality in our study; our estimates fit the broad range of contributions reported by previous studies, including a 56% reduction of the educational gradient in mortality in the British Whitehall study and a 17% reduction in the French GAZEL study.[12]

However, type of employment was more important in explaining educational inequalities in all-cause mortality for men than for women. Unemployment was more strongly associated with mortality and more strongly educational patterned among men than among women. In contrast, the occupational class of the breadwinner was more important in explaining educational inequalities in mortality for women than for men. Although a weaker educational gradient in blue collar occupation of the breadwinner was found among women than among men, its stronger association with mortality for women resulted in a larger contribution of this factor to the explanation of educational inequalities in mortality for women than for men. As a large proportion of the women in our sample were outside the labor force, i.e. 57% of all women, the occupational class of the breadwinner may thus possibly be a better representative of their social class than their own employment status. However, for men it seemed that having a job outweighed the prestige associated with that job. This is likely to explain the gender differences in the contribution of our employment-related factors to explaining educational inequalities in mortality. However, we did not find evidence of gender differences in the explanation of educational inequalities in mortality for the other explanatory variables. Thus even though there were gender differences in the educational gradient as well as the association with mortality for some of our other variables (e.g., being previously married and living alone), our results showed that these differences were not large enough to lead to gender differences in explanations or were compensating each other.

Besides material, employment-related, and behavioral factors, we also examined whether family-related factors play a role in explaining educational inequalities in mortality, as we know that they are associated with mortality. Our results suggest that marital status, living arrangement, and number of children did not contribute to the explanation of socioeconomic inequalities in mortality for either men or women. For example, even though being previously married was more strongly associated with mortality for men than for women, marital status was less socially patterned among men than women, and thus no significant differences in the contribution of marital status to socioeconomic inequalities in mortality by gender were found. Our results may well have depended on the relatively broad measures of family-related factors, such as legal marital status and the number of children in the household, that were included. Therefore, we recommend future studies to take into account more specific family-related factors or even full family life histories in a longitudinal analysis, to advance our knowledge on how family-related factors may contribute to educational inequalities in mortality.

In the cause-specific analysis, we found that our explanatory variables explained a substantial part of educational inequalities in mortality for cardiovascular disease (CVD) for men, but not for women. Our results are partly in line with previous results;[50] a substantial contribution of material factors in the explanation of educational inequalities in CVD mortality for men, and the largest contribution of behavioral factors in the explanation of educational inequalities in CVD mortality for women. Surprisingly however, material factors did not contribute to the explanation of educational inequalities in CVD mortality for women, but it explained a substantial part of their educational inequalities in all-cause mortality and mortality from the other causes (cancer, other diseases, and external causes). This warrants further investigation.

Conclusions

Our findings highlight the importance of a gender perspective in research on educational inequalities in mortality and the factors contributing to the explanation of these inequalities, as the contributions of these factors differed for men and women. Policies targeting the reduction of educational inequalities in mortality should focus on improving material circumstances and discouraging unhealthy behaviors, and would also benefit from a gendered approach as interventions addressing specific factors may have differential effects on educational inequalities for men and women.

In conclusion, unemployment seemed more important in explaining educational inequalities in mortality for men than for women, whereas social class of the breadwinner was more important for the explanation for women than for men. A full understanding of educational inequalities in mortality thus benefits from a gender perspective, particularly when considering employment-related factors.

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SUPPLEMENTAL MATERIALS

TABLE A – Age-standardized distribution of educational level for men and women, at baseline 1991

Level of education	Men, proportion (95% CI)	Women, proportion (95% CI)
Lowest	19.1 (18.1, 20.2)	25.2 (24.2, 26.2)
Low	33.2 (31.9, 34.4)	47.3 (46.2, 48.5)
Mid	22.2 (21.2, 23.3)	17.0 (16.2, 17.9)
High	25.5 (24.3, 26.6)	10.4 (9.7, 11.1)

Note. CI: confidence interval.

TABLE B – Contributions of the explanatory factors to educational inequalities in all-cause mortality for low educated men and women

	Men						Women					
	Level of education			Change in educational inequality			Level of education			Change in educational inequality		
	Low		High	Absolute decline[a]	Percentage decline[a]		Low		High	Absolute decline[a]	Percentage decline[a]	
Models	HR	(95% CI)	Ref.		%	(95% CI)[b]	HR	(95% CI)	Ref.		%	(95% CI)[b]
0. No additional controls	1.28	(1.11, 1.47)	1				1.44	(1.13, 1.83)	1			
1. Material	1.03	(0.88, 1.21)	1	0.25	89%	(51%, 202%)	1.27	(0.99, 1.63)	1	0.17	39%	(19%, 93%)
Financial difficulties	1.24	(1.08, 1.43)	1	0.04	14%	(3%, 31%)	1.40	(1.10, 1.78)	1	0.04	9%	(4%, 26%)
Housing tenure	1.16	(1.00, 1.34)	1	0.12	43%	(22%, 97%)	1.34	(1.05, 1.71)	1	0.10	23%	(10%, 53%)
Health insurance	1.09	(0.94, 1.28)	1	0.19	68%	(34%, 152%)	1.32	(1.04, 1.69)	1	0.12	27%	(12%, 64%)
2. Employment-related	1.22	(1.03, 1.44)	1	0.06	21%	(−15%, 77%)	1.31	(1.02, 1.69)	1	0.13	30%	(−3%, 51%)
Employment	1.22	(1.06, 1.40)	1	0.06	21%	(12%, 53%)	1.47	(1.15, 1.88)	1	−0.03	−7%	(−30%, 2%)
Occ. of the breadwinner[c]	1.24	(1.05, 1.47)	1	0.04	14%	(−27%, 60%)	1.28	(0.99, 1.64)	1	0.16	36%	(6%, 63%)
3. Behavioral factors	1.18	(1.02, 1.36)	1	0.10	36%	(10%, 75%)	1.33	(1.04, 1.69)	1	0.11	25%	(3%, 78%)
Alcohol consumption	1.26	(1.10, 1.45)	1	0.02	7%	(−7%, 17%)	1.47	(1.15, 1.87)	1	−0.03	−7%	(−26%, 6%)
BMI	1.25	(1.09, 1.44)	1	0.03	11%	(0%, 24%)	1.44	(1.13, 1.84)	1	0.00	0%	(−10%, 7%)
Smoking	1.26	(1.09, 1.45)	1	0.02	7%	(−12%, 29%)	1.38	(1.08, 1.75)	1	0.06	14%	(−2%, 48%)
Leisure activity	1.27	(1.10, 1.46)	1	0.01	4%	(−4%, 12%)	1.41	(1.11, 1.79)	1	0.03	7%	(−2%, 21%)
Sports activity	1.23	(1.06, 1.41)	1	0.05	18%	(9%, 45%)	1.39	(1.09, 1.77)	1	0.05	11%	(2%, 33%)
4. Family-related factors	1.30	(1.13, 1.50)	1	−0.02	−7%	(−27%, 3%)	1.50	(1.17, 1.91)	1	−0.06	−14%	(−46%, −0%)
Marital status	1.31	(1.14, 1.51)	1	−0.03	−11%	(−28%, −1%)	1.49	(1.17, 1.90)	1	−0.05	−11%	(−41%, 0%)
Living arrangement	1.30	(1.13, 1.49)	1	−0.02	−7%	(−21%, 1%)	1.46	(1.15, 1.85)	1	−0.02	−5%	(−16%, 0%)
Number of children	1.27	(1.11, 1.47)	1	0.01	4%	(−4%, 11%)	1.50	(1.17, 1.91)	1	−0.06	−14%	(−40%, −2%)
5. All factors	1.11	(0.93, 1.33)	1	0.17	61%	(12%, 152%)	1.21	(0.93, 1.58)	1	0.23	52%	(5%, 120%)

Notes. HR: mortality hazard ratios; CI: confidence interval; Ref: reference category. [a] Negative absolute and percentage declines indicate an increase in the educational inequality. [b] Confidence intervals (CIs) of the percentage decline were calculated using bootstraps with 5000 repetitions; 1000 repetitions per imputed dataset. [c] Occ.: Occupation.

TABLE C – Contributions of the explanatory factors to educational inequalities in all-cause mortality for mid educated men and women

	Men						Women					
	Level of education			Change in educational inequality			Level of education			Change in educational inequality		
	Mid		High	Absolute decline[a]	Percentage decline[a]		Mid		High	Absolute decline[a]	Percentage decline[a]	
Models	HR	(95% CI)	Ref.		%	(95% CI)[b]	HR	(95% CI)	Ref.		%	(95% CI)[b]
0. No additional controls	1.18	(1.01, 1.38)	1				1.46	(1.11, 1.91)	1			
1. Material	1.06	(0.90, 1.24)	1	0.12	67%	(27%, 378%)	1.37	(1.05, 1.80)	1	0.09	20%	(8%, 55%)
Financial difficulties	1.17	(1.00, 1.37)	1	0.01	6%	(0%, 42%)	1.44	(1.10, 1.89)	1	0.02	4%	(−1%, 13%)
Housing tenure	1.13	(0.96, 1.32)	1	0.05	28%	(11%, 164%)	1.41	(1.07, 1.85)	1	0.05	11%	(4%, 33%)
Health insurance	1.09	(0.93, 1.28)	1	0.09	50%	(18%, 267%)	1.40	(1.07, 1.84)	1	0.06	13%	(5%, 36%)
2. Employment-related	1.14	(0.97, 1.35)	1	0.04	22%	(−20%, 115%)	1.41	(1.07, 1.85)	1	0.05	11%	(−8%, 21%)
Employment	1.15	(0.98, 1.34)	1	0.03	17%	(2%, 106%)	1.49	(1.14, 1.95)	1	−0.03	−7%	(−26%, −0%)
Occ. of the breadwinner[c]	1.16	(0.98, 1.37)	1	0.02	11%	(−37%, 67%)	1.37	(1.05, 1.81)	1	0.09	20%	(3%, 35%)
3. Behavioral factors	1.16	(0.99, 1.35)	1	0.02	11%	(−38%, 103%)	1.40	(1.06, 1.83)	1	0.06	13%	(−12%, 58%)
Alcohol consumption	1.17	(1.00, 1.37)	1	0.01	6%	(−25%, 33%)	1.47	(1.12, 1.92)	1	−0.01	−2%	(−15%, 14%)
BMI	1.17	(1.00, 1.37)	1	0.01	6%	(−4%, 36%)	1.48	(1.13, 1.94)	1	−0.02	−4%	(−17%, 2%)
Smoking	1.19	(1.02, 1.40)	1	−0.01	−6%	(−72%, 37%)	1.40	(1.07, 1.84)	1	0.06	13%	(−7%, 48%)
Leisure activity	1.18	(1.01, 1.38)	1	0.00	0%	(−18%, 21%)	1.44	(1.10, 1.88)	1	0.02	4%	(−4%, 22%)
Sports activity	1.16	(0.99, 1.36)	1	0.02	11%	(−3%, 62%)	1.45	(1.11, 1.90)	1	0.01	2%	(−8%, 16%)
4. Family-related factors	1.22	(1.04, 1.42)	1	−0.04	−22%	(−117%, 3%)	1.49	(1.13, 1.95)	1	−0.03	−7%	(−27%, 5%)
Marital status	1.22	(1.04, 1.42)	1	−0.04	−22%	(−109%, −2%)	1.48	(1.13, 1.94)	1	−0.02	−4%	(−21%, 4%)
Living arrangement	1.21	(1.03, 1.41)	1	−0.03	−17%	(−78%, 2%)	1.46	(1.12, 1.92)	1	0.00	0%	(−9%, 6%)
Number of children	1.17	(1.00, 1.37)	1	0.01	6%	(−8%, 34%)	1.49	(1.14, 1.96)	1	−0.03	−7%	(−24%, 2%)
5. All factors	1.12	(0.95, 1.32)	1	0.06	33%	(−45%, 201%)	1.33	(1.01, 1.76)	1	0.13	28%	(−15%, 72%)

Notes. HR: mortality hazard ratios; CI: confidence interval; Ref: reference category. [a] Negative absolute and percentage declines indicate an increase in the educational inequality. [b] Confidence intervals (CIs) of the percentage decline were calculated using bootstraps with 5000 repetitions; 1000 repetitions per imputed dataset. [c] Occ.: Occupation.

Chapter 5

Marital status, labor force activity and mortality: A study in the US and 6 European countries

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ABSTRACT

Objectives. Labor force activity and marriage share some pathways through which they potentially influence health. In this paper, we examine whether marriage and labor force participation interact in the way they influence mortality in the United States (US) and six European countries.

Methods. We used data from the US National Health Interview Survey linked to the National Death Index, and national mortality registry data for Austria, England and Wales, Finland, Hungary, Norway, and Spain (specifically, the Basque country) during 1999–2007, for men and women aged 30–59 years at baseline. We used Poisson regression to estimate both the additive (relative excess risk due to interaction) and multiplicative interactions between marriage and labor force activity on mortality.

Results. Labor force inactivity was associated with higher mortality, but this association was stronger for unmarried, rather than married, individuals. Likewise, being unmarried was associated with higher mortality, but this association was stronger for inactive than for active individuals. To illustrate, among US women out of the labor force, being unmarried was associated with a 3.98 times (95% CI: 3.28, 4.82) higher risk of dying than being married; whereas the relative risk (RR) was 2.49 (95% CI: 2.10, 2.94), for women who were active in the labor market. Although this interaction between marriage and labor force activity was only significant for women on a multiplicative scale, there was a significant additive interaction for both men and women. The pattern was similar across all countries.

Conclusions. Marriage attenuated the increased mortality risk associated with labor force inactivity; while labor force activity attenuated the mortality risk associated with being unmarried. Our study emphasizes the importance of public health and social policies that improve the health and well-being of unmarried and inactive men and women.

INTRODUCTION

Married persons and individuals active in the labor force enjoy better health and lower mortality than unmarried and inactive individuals.[1–6] Marriage offers a direct form of social and financial support[1,2,4] and it can reduce the risk of unhealthy behaviors, such as poor diet or alcohol use.[1,2,7] Labor force activity could provide financial independence and the possibility to accumulate earnings and wealth.[8] It may also provide a source of social support, social recognition and self-esteem; and it could positively influence some health behaviours.[4,5,9] The fact that labor force activity and marriage share some of the pathways through which they potentially influence health raises the possibility that they interact in the way that they influence health and mortality. For example, the lack of a partner's social support for a divorced man or woman may be partly compensated by the availability of social support derived from colleagues and friends at work. Similarly, the lack of financial security provided by one's own earnings from work could be compensated by the presence of a partner who is active in the labor market.

A substantial body of research has looked into whether combining employment, marriage and/or parenthood is associated with health.[10–12] Some of the theories on combining multiple roles may be useful to understand these relationships. The role accumulation hypothesis postulates that having multiple roles provides benefits for women, as employment provides financial independence and social support.[10,11] On the other hand, the multiple role hypothesis suggests that combining employment, marriage, and parenthood may be harmful to women's health, due to increased stress from competing demands.[10,11,13] Fulfilling the obligations of each role may lead to role overload and conflict, which may result in increased risk of disease and mortality.[14]

There are important gender differences in the distribution of multiple roles, as well as role expectations, between men and women, which may lead to different associations with health and mortality.[15,16] For example, role expectations imply that in many countries, men are more often expected to be active in the labor market than women. As a result, being out of the labor force may lead to more stress and health deterioration for males than for females. Also, there may be gender differences in the selection processes leading to marriage and employment: Men out of the labor force may be a more selective group, in terms of poor health and disability; while women may be out of the labor market more often out of choice, particularly women who are married.

The interaction between marriage and labor force activity may differ across countries with different social protection policies. For example, in the US, unemployment insurance income benefits are substantially less generous than in the Scandinavian countries.[17] This is also reflected in the net replacement rates, which express the average of the net unemployment benefits; the net replacement rates are lowest in the US and highest in Norway.[18] As a result, US workers might face more financial strain during unemployment than workers in Norway, particularly if they lack the financial support of a partner. Similarly, income support programs might help by buffering against the negative effects of being a lone parent, particularly for men and women who are also out of the labor force.

In this study, we examined whether labor force activity and marriage interact in their association with mortality, across the US and six European countries. For each country, we examined whether labor force activity modified the association between marriage and mortality, and whether marital status modified the association between labor force activity and mortality. We hypothesized that marriage attenuates the mortality risk associated with labor force inactivity, while labor force activity attenuates the mortality risk associated with being unmarried. Additionally, we hypothesized that this buffering effect is stronger in countries where there are limited social protection programs for individuals out of the labor force, such as the US and Hungary.

As pointed out by Knol and VanderWeele in 2012,[19] interaction can occur on both an additive scale and a multiplicative scale, and it is not clear theoretically whether one should be more important than the other. Often, the additive scale is of more interest from a public health perspective, i.e. whether more cases occur when two exposures occur together, even if there is no multiplicative interaction; however, multiplicative interactions may be relevant, if relationships between the variables studied are believed to relate to each other in a multiplicative way, i.e. exposure of variable 'A' might double or triple the risk, if exposure 'B' is present. In epidemiology, it is now recommended that both additive and multiplicative interactions are presented. In this study, we therefore examine both multiplicative and additive interactions between marriage and labor force activity.

METHODS

Data sources

Census data from 1999–2001 were linked to national mortality registries, with a follow-up until 2002–2007, for six European countries or regions: Austria, England and Wales (in UK), Finland, Hungary, Norway, and the Basque country (in Spain).[20] The data comprised entire populations, except for England and Wales (a 1% representative sample of the population) and Finland (a random sample of 80% of the population). Our analyses were restricted to individuals aged 30–59 years at baseline, to minimize inclusion of individuals who were out of the labor force due to retirement. The analysis covered 196,276 deaths among more than 10 million European individuals.

For the US analysis, five waves covering the years 1999 to 2003 of the National Health Interview Survey (NHIS), a multipurpose health survey among the US civilian, non-institutionalized population,[21] were combined with a 5-year mortality follow-up from the National Death Index. The analysis included 14,069 deaths among 431,659 Americans aged 30–59 years at baseline. Large racial differences in mortality have been documented for the US,[22] as well as differences in the joint distribution of marital status and employment. To avoid that our US results would be driven by racial disparities, we also show analyses separately for US blacks and whites. Unfortunately, data on mortality by race were not available for the European countries; however, we expected that racial disparities would be most dramatic in the US context. Detailed information on the US and European data can be found in the supplemental materials (Table A).

Variables

We classified individuals into two broad groups based on their legal marital status:

1. Married, including married but separated individuals (as they cannot be distinguished from married persons in the European data); and
2. Unmarried, which is comprised of widowed, divorced, and never married individuals (taken together to account for small sample sizes of the categories widowed and divorced individuals).

Individuals were considered to be active in the labor market if they were currently employed or currently experiencing an unemployment spell, while they were considered to be inactive if they were out of the labor market. The inactive category included individuals who were homemakers, sick or disabled, retired, and in education (students); however, our analyses were restricted to ages 30–59 years; and therefore, we expected the fraction of individuals in this category as a result of long-term sickness, being educated or retirement to be relatively small.

We controlled for education in all models, as educational attainment is associated with mortality, as well as marital status and labor force activity status. The subjects' educational levels were grouped into three categories:

- Lower secondary or less education (≤11 years of schooling, International Standard Classification of Education[23] (ISCED) levels 0 to 2);
- Upper secondary education (12–15 years of schooling, ISCED levels 3 and 4); and
- Tertiary or more education (≥16 years of schooling, ISCED levels 5 and 6).

Analysis

Mortality rates were derived from Poisson regression models, stratified by gender and directly standardized to the US 2005 intercensal population. The separated, combined, and stratified associations of marital status and labor force activity with mortality were estimated and presented as rate ratios (RRs) with 95% confidence intervals (CIs).

Following the recommendations by Knol and VanderWeele,[19] we presented measures of interaction (and CIs) on the additive and multiplicative scale. Both measures were calculated using the combined RRs of marital status and labor force activity, taking married and active persons as the reference category. The relative excess risk due to interaction (RERI), which is an interaction measure on the additive scale, represents the proportion of disease among those with both exposures that is attributable to their interaction,[19,24] is shown in Equation 1:

$$RERI = RR_{unmarried,inactive} - RR_{married,inactive} - RR_{unmarried,active} + 1 \quad (1)$$

An additive interaction is found when the RERI significantly differs from 0, and can be positive (RERI > 0, when unmarried individuals who are inactive in the labor market are worse off than would be expected, based on the independent relative effects; $RR_{unmarried,inactive} > RR_{married,inactive} + RR_{unmarried,active} - 1$) or negative (RERI < 0, when unmarried individuals who are inactive in the labor market are better off than would be expected; $RR_{unmarried,inactive} < RR_{married,inactive} + RR_{unmarried,active} - 1$)

A multiplicative interaction (MI) is estimated as follows, in Equation 2:

$$MI = RR_{unmarried,inactive} / (RR_{married,inactive} \times RR_{unmarried,active}) \quad (2)$$

A multiplicative interaction is present when the MI is significantly different from 1, and can be positive (MI > 1, when unmarried individuals who are inactive in the labor market are worse off than would be expected; $RR_{unmarried,inactive} > [RR_{married,inactive} \times RR_{unmarried,active}]$) or negative (MI < 1, when unmarried individuals who are inactive in the labor market are better off than would be expected; $RR_{unmarried,inactive} < [RR_{married,inactive} \times RR_{unmarried,active}]$). Data were analyzed using Stata version 12 (StataCorp, College Station, TX, US).

RESULTS

Marital status and labor force activity

The population distribution by marital status and labor force activity differed considerably between countries (Table 1 for men and Table 2 for women). The proportion of unmarried persons ranged from 29% (Hungary) to 54% (US blacks) for men; and from 27% (Basque country, Spain) to 67% (US blacks) for women. The proportion of men inactive in the labor force was larger in the US (whites 24% and blacks 26%) than in Europe, where it ranged from 9% (Austria and the Basque country, Spain) to 14% (Norway), except for Hungary (24%). The percentage of women inactive in the labor force ranged between 14% (Finland) and 41% (Basque country, Spain).

TABLE 1 – **Distribution, mortality rates, and rate ratios of marital status and labor force activity for men aged 30–59 years, in seven countries**

	US, all	US, whites	US, blacks	Austria	England and Wales	Finland	Hungary	Norway	Spain, Basque country
Percentage									
Married	62	65	46	66	66	57	71	58	68
Unmarried	38	35	54	34	34	43	29	42	32
Active	77	76	74	91	87	88	76	86	91
Inactive	23	24	26	9	13	12	24	14	9
Mortality rate per 100,000 person-years (95% CI)									
Married	314 (293, 335)	287 (264, 310)	568 (474, 663)	285 (275, 295)	225 (210, 241)	261 (256, 267)	691 (685, 698)	223 (217, 228)	263 (255, 270)
Unmarried	695 (643, 746)	649 (589, 708)	1003 (839, 1166)	664 (639, 689)	472 (438, 506)	695 (685, 706)	1565 (1549, 1582)	526 (515, 538)	568 (548, 589)
Active	290 (271, 309)	277 (256, 299)	426 (357, 495)	257 (249, 266)	217 (203, 230)	343 (338, 348)	612 (605, 618)	225 (221, 230)	271 (263, 278)
Inactive	1211 (1103, 1319)	1036 (917, 1154)	2152 (1798, 2505)	1191 (1136, 1245)	786 (722, 851)	1039 (1017, 1061)	1547 (1531, 1563)	883 (860, 905)	903 (863, 942)
Total	413 (393, 434)	378 (356, 399)	747 (657, 837)	385 (376, 395)	300 (285, 314)	441 (435, 446)	935 (929, 942)	330 (324, 335)	336 (328, 343)
Rate ratio (95% CI)									
Unmarried versus married	2.21 (2.00, 2.45)	2.26 (1.99, 2.57)	1.76 (1.41, 2.21)	2.33 (2.21, 2.45)	2.09 (1.90, 2.31)	2.66 (2.60, 2.73)	2.26 (2.23, 2.30)	2.36 (2.29, 2.44)	2.17 (2.06, 2.27)
Inactive versus active	4.17 (3.70, 4.70)	3.73 (3.20, 4.35)	5.05 (4.05, 6.31)	4.63 (4.36, 4.91)	3.63 (3.27, 4.02)	3.03 (2.95, 3.10)	2.53 (2.49, 2.57)	3.92 (3.79, 4.05)	3.34 (3.17, 3.51)

Notes. CI: confidence interval. Mortality rates and rate ratios were obtained from Poisson regression models adjusted for age and education.

TABLE 2 – **Distribution, mortality rates, and rate ratios of marital status and labor force activity for women aged 30–59 years, in seven countries**

	US, all	US, whites	US, blacks	Austria	England and Wales	Finland	Hungary	Norway	Spain, Basque country
Percentage									
Married	56	60	33	68	66	61	69	62	73
Unmarried	44	40	67	32	34	39	31	38	27
Active	61	61	66	69	71	86	63	77	59
Inactive	39	39	34	31	29	14	37	23	41
Mortality rate per 100,000 person-years (95% CI)									
Married	208 (190, 226)	194 (173, 214)	379 (300, 458)	150 (143, 157)	155 (143, 168)	142 (138, 146)	295 (290, 299)	165 (161, 170)	124 (118, 129)
Unmarried	385 (352, 419)	364 (324, 404)	528 (446, 610)	292 (276, 307)	259 (235, 283)	271 (264, 278)	498 (490, 506)	301 (292, 310)	211 (198, 223)
Active	172 (156, 189)	155 (137, 174)	271 (220, 322)	118 (111, 125)	122 (111, 133)	140 (137, 144)	198 (194, 202)	140 (136, 144)	112 (106, 118)
Inactive	497 (452, 541)	468 (417, 518)	971 (798, 1143)	301 (286, 316)	344 (315, 373)	480 (466, 494)	580 (571, 588)	411 (398, 423)	181 (172, 190)
Total	267 (250, 283)	242 (224, 261)	469 (415, 523)	192 (185, 199)	188 (176, 199)	192 (188, 195)	361 (357, 365)	211 (206, 215)	144 (139, 149)
Rate ratio (95% CI)									
Unmarried versus married	1.86 (1.64, 2.10)	1.88 (1.61, 2.19)	1.39 (1.05, 1.85)	1.94 (1.81, 2.08)	1.67 (1.48, 1.89)	1.91 (1.84, 1.98)	1.69 (1.65, 1.73)	1.82 (1.75, 1.90)	1.70 (1.58, 1.83)
Inactive versus active	2.88 (2.51, 3.30)	3.01 (2.54, 3.56)	3.58 (2.69, 4.77)	2.56 (2.36, 2.77)	2.82 (2.49, 3.20)	3.42 (3.29, 3.55)	2.92 (2.84, 3.00)	2.94 (2.82, 3.06)	1.62 (1.50, 1.74)

Notes. CI: confidence interval. Mortality rates and rate ratios were obtained from Poisson regression models adjusted for age and education.

TABLE 3 – Mortality rates and rate ratios for the combined effect of marital status and labor force activity for men and women aged 30–59 years, in seven countries

	US, all	US, whites	US, blacks	Austria	England and Wales	Finland	Hungary	Norway	Spain, Basque country
Men									
Mortality rate per 100,000 person-years (95% CI)									
Married and active	243 (222, 263)	228 (205, 251)	355 (273, 436)	197 (189, 206)	182 (167, 196)	216 (211, 221)	433 (426, 439)	187 (182, 192)	221 (213, 228)
Unmarried and active	446 (401, 491)	448 (395, 500)	548 (408, 688)	432 (411, 454)	307 (276, 337)	545 (535, 555)	1185 (1166, 1204)	309 (299, 319)	439 (419, 458)
Married and inactive	898 (782, 1014)	765 (640, 890)	1810 (1350, 2271)	889 (834, 943)	559 (490, 629)	660 (635, 685)	1257 (1240, 1274)	517 (492, 542)	708 (665, 752)
Unmarried and inactive	1632 (1450, 1814)	1441 (1232, 1651)	2426 (1928, 2924)	1617 (1522, 1711)	1062 (952, 1172)	1313 (1281, 1345)	2044 (2015, 2073)	1175 (1141, 1210)	1211 (1136, 1285)
Total	413 (393, 434)	378 (356, 399)	747 (657, 837)	385 (376, 395)	300 (285, 314)	441 (435, 446)	935 (929, 942)	330 (324, 335)	336 (328, 343)
Rate ratio (95% CI)									
Married and active (Ref)	1	1	1	1	1	1	1	1	1
Unmarried and active	1.84 (1.61, 2.09)	1.97 (1.69, 2.29)	1.55 (1.08, 2.22)	2.19 (2.05, 2.34)	1.69 (1.48, 1.92)	2.52 (2.45, 2.59)	2.74 (2.68, 2.80)	1.65 (1.58, 1.73)	1.99 (1.88, 2.10)
Married and inactive	3.70 (3.13, 4.36)	3.36 (2.74, 4.13)	5.11 (3.60, 7.25)	4.50 (4.17, 4.86)	3.08 (2.66, 3.57)	3.05 (2.92, 3.19)	2.91 (2.85, 2.97)	2.77 (2.62, 2.93)	3.21 (3.00, 3.44)
Unmarried and inactive	6.72 (5.81, 7.78)	6.33 (5.22, 7.68)	6.84 (5.12, 9.15)	8.19 (7.61, 8.82)	5.85 (5.13, 6.66)	6.07 (5.87, 6.28)	4.72 (4.62, 4.82)	6.29 (6.04, 6.55)	5.49 (5.11, 5.89)
Women									
Mortality rate per 100,000 person-years (95% CI)									
Married and active	139 (122, 156)	126 (107, 145)	243 (167, 318)	91 (84, 99)	108 (95, 120)	113 (109, 116)	165 (161, 170)	124 (119, 128)	97 (90, 104)
Unmarried and active	232 (201, 263)	220 (183, 258)	285 (215, 354)	164 (150, 178)	153 (131, 175)	188 (182, 194)	270 (262, 278)	174 (166, 182)	147 (134, 159)
Married and inactive	359 (318, 400)	352 (304, 400)	731 (512, 951)	228 (214, 242)	271 (240, 302)	333 (318, 349)	472 (463, 482)	295 (282, 308)	149 (141, 158)
Unmarried and inactive	872 (759, 984)	887 (734, 1040)	1146 (893, 1399)	566 (525, 607)	500 (439, 561)	663 (638, 688)	806 (789, 823)	596 (572, 619)	356 (326, 386)
Total	267 (250, 283)	242 (224, 261)	469 (415, 523)	192 (185, 199)	188 (176, 199)	192 (188, 195)	361 (357, 365)	211 (206, 215)	144 (139, 149)
Rate ratio (95% CI)									
Married and active (Ref)	1	1	1	1	1	1	1	1	1
Unmarried and active	1.67 (1.41, 1.98)	1.74 (1.40, 2.17)	1.17 (0.78, 1.76)	1.80 (1.61, 2.03)	1.42 (1.18, 1.71)	1.66 (1.59, 1.74)	1.63 (1.57, 1.70)	1.41 (1.33, 1.49)	1.51 (1.36, 1.68)
Married and inactive	2.58 (2.20, 3.04)	2.79 (2.29, 3.38)	3.01 (1.92, 4.73)	2.50 (2.26, 2.78)	2.52 (2.14, 2.96)	2.95 (2.79, 3.13)	2.86 (2.76, 2.96)	2.38 (2.25, 2.52)	1.54 (1.40, 1.69)
Unmarried and inactive	6.27 (5.21, 7.55)	7.02 (5.53, 8.90)	4.72 (3.12, 7.14)	6.21 (5.55, 6.95)	4.65 (3.93, 5.50)	5.87 (5.59, 6.17)	4.87 (4.71, 5.05)	4.81 (4.55, 5.08)	3.67 (3.28, 4.10)

Notes. CI: confidence interval; Ref: reference category. Mortality rates and rate ratios were obtained from Poisson regression models adjusted for age and education.

TABLE 4 – **Rate ratios of marital status within strata of labor force activity and rate ratios of labor force activity within strata of marital status for men and women aged 30–59 years, in seven countries**

	US, all	US, whites	US, blacks	Austria	England and Wales	Finland	Hungary	Norway	Spain, Basque country
Men									
Marital status									
Married									
Inactive versus active (95% CI)	3.56 (3.00, 4.21)	3.18 (2.58, 3.91)	5.24 (3.53, 7.77)	4.73 (4.35, 5.14)	3.06 (2.63, 3.55)	3.03 (2.90, 3.17)	2.92 (2.86, 2.99)	2.72 (2.57, 2.88)	3.21 (2.99, 3.44)
Unmarried									
Inactive versus active (95% CI)	3.80 (3.25, 4.45)	3.42 (2.81, 4.15)	4.43 (3.15, 6.22)	3.56 (3.28, 3.87)	3.48 (3.00, 4.03)	2.41 (2.34, 2.49)	1.72 (1.68, 1.76)	3.85 (3.68, 4.02)	2.75 (2.55, 2.97)
Labor force activity									
Active									
Unmarried versus married (95% CI)	1.86 (1.63, 2.11)	1.97 (1.69, 2.30)	1.53 (1.06, 2.20)	2.21 (2.06, 2.36)	1.73 (1.52, 1.97)	2.52 (2.45, 2.60)	2.67 (2.61, 2.73)	1.71 (1.64, 1.79)	2.02 (1.91, 2.14)
Inactive									
Unmarried versus married (95% CI)	1.78 (1.52, 2.10)	1.86 (1.51, 2.30)	1.34 (0.99, 1.83)	1.70 (1.57, 1.85)	1.81 (1.54, 2.12)	1.98 (1.90, 2.07)	1.64 (1.61, 1.68)	2.17 (2.05, 2.30)	1.59 (1.46, 1.74)
Women									
Marital status									
Married									
Inactive versus active (95% CI)	2.49 (2.10, 2.94)	2.68 (2.19, 3.28)	3.03 (1.92, 4.79)	2.33 (2.09, 2.60)	2.54 (2.15, 2.99)	3.00 (2.84, 3.18)	2.85 (2.75, 2.95)	2.38 (2.24, 2.52)	1.55 (1.41, 1.71)
Unmarried									
Inactive versus active (95% CI)	3.98 (3.28, 4.82)	4.31 (3.31, 5.62)	4.00 (2.85, 5.62)	3.93 (3.47, 4.45)	3.21 (2.64, 3.90)	3.47 (3.31, 3.65)	3.00 (2.88, 3.12)	3.43 (3.22, 3.65)	2.45 (2.16, 2.77)
Labor force activity									

TABLE 4 – **Rate ratios of marital status within strata of labor force activity and rate ratios of labor force activity within strata of marital status for men and women aged 30–59 years, in seven countries (continued)**

	US, all	US, whites	US, blacks	Austria	England and Wales	Finland	Hungary	Norway	Spain, Basque country
Active									
Unmarried versus married (95% CI)	1.64 (1.39, 1.95)	1.73 (1.38, 2.15)	1.16 (0.78, 1.72)	1.80 (1.60, 2.02)	1.44 (1.19, 1.73)	1.65 (1.58, 1.73)	1.60 (1.54, 1.67)	1.42 (1.34, 1.51)	1.50 (1.35, 1.67)
Inactive									
Unmarried versus married (95% CI)	2.47 (2.10, 2.91)	2.56 (2.06, 3.17)	1.57 (1.07, 2.30)	2.51 (2.30, 2.75)	1.83 (1.56, 2.16)	1.98 (1.86, 2.10)	1.71 (1.66, 1.75)	2.00 (1.89, 2.12)	2.40 (2.17, 2.66)

Notes. CI: confidence interval. Rate ratios were obtained from Poisson regression models adjusted for age and education.

Marital status, labor force activity, and mortality

Mortality rates were generally higher for Americans than for Europeans; US mortality rates were exceeded only by those for Hungary and Finland (only for men). For men and women in all countries, mortality was higher among unmarried persons and persons inactive in the labor force (Table 1 and Table 2). The RRs of mortality, when comparing unmarried and married individuals, ranged from 1.76 (US blacks, 95% CI: 1.41, 2.21) to 2.66 for men (Finland, 95% CI: 2.60, 2.73); and from 1.39 (US blacks, 95% CI: 1.05, 1.85) to 1.94 for women (Austria, 95% CI: 1.81, 2.08). Overlapping CIs suggested that the association between marital status and mortality did not differ across countries. We found the only significantly higher RR to be in Finnish men.

The RRs of mortality, when comparing inactive versus active labor force status, ranged from 2.53 (Hungary, 95% CI: 2.23, 2.30) to 5.05 for men (US blacks, 95% CI: 4.05, 6.31); and from 1.62 (Basque country in Spain, 95% CI: 1.50, 1.74) to 3.58 for women (US blacks, 95% CI: 2.90, 4.77). Again the CIs overlapped in all countries, which suggested that there were no cross-national differences in the association between labor force activity and mortality.

Marital status and labor force activity combined and mortality

Table 3 shows that in all countries, mortality was lowest for married men and women active in the labor force, and highest for unmarried men and women who were inactive in the labor force. In most countries, mortality was higher for married individuals who were inactive in the labor force than for unmarried individuals who were active in the labor force; however, the CIs for most groups in the different countries overlapped, suggesting that the associations of marital status, labor force activity, and mortality were not significantly different across countries. Information on the differences in the joint distribution of marital status and labor force activity between the countries is provided in Table B (available in the supplemental materials).

The buffering of marital status and labor force activity

Labor force inactivity was associated with higher mortality for both married and unmarried men and women (Table 4). Labor force inactivity was more strongly associated with mortality among married men in Austria, Finland, Hungary, Spain (Basque country), and US black men; and among unmarried men in England and Wales, Norway, and US white men; however, many RRs had overlapping CIs, which indicated that they were not significantly different for married and unmarried men. Labor force inactivity was more strongly associated with mortality for unmarried women than for married women. Non-overlapping CIs were found in US whites (only), and in Austria, Finland, Norway, and Spain (Basque country). The magnitude of the RRs was similar for men and women.

Being unmarried was more strongly associated with mortality for men active in the labor force than for inactive men (Table 4). Most, but not all, RRs had overlapping CIs. For example, among Hungarian men who were active in the labor force, being unmarried was associated with a 2.67 (95% CI: 2.61, 2.73) times higher risk of dying than being married, whereas the same risk was 1.64 (95% CI: 1.61, 1.68) times for men who were not active in the labor force. Being unmarried was associated with a significantly higher risk of mortality for women in all countries, except for US black women. This association was stronger for women who were inactive in the labor force than for women active in the labor force, and these were significantly different from each other in the US, Austria, Finland, Norway, and the Basque country in Spain.

Results in Figure 1 summarize the findings of our models assessing the additive and multiplicative interactions between marital status and labor force activity on mortality. The RERI was, in most cases, statistically significant for men, except for Hungarian and US black men (Figure 1). The significant RERIs ranged from 1.29 (Basque country in Spain, 95% CI: 0.69, 1.88) to 2.87 (Norway, 95% CI: 2.39, 3.35). The RERI was significant and positive for women in all countries: it was smallest in Hungary (RERI=1.38, 95% CI: 1.00, 1.76) and largest for US whites (RERI=3.49, 95% CI: 2.08, 4.90). These positive RERIs indicated that unmarried men and women who were inactive in the labor force were worse off than would be expected, based on the independent relative effects of being unmarried or inactive alone. In other words, being inactive in the labor market was associated with higher mortality compared to being active, but this association was stronger for the unmarried than for those who were married. Likewise, being unmarried was associated with higher mortality, but this association was stronger for those who were inactive in the labor market.

For men, the multiplicative interaction (MI) was significant for Finland, Hungary, Norway, and Spain (Basque country): MI was smaller than 1 for Finland (MI=0.79, 95% CI: 0.71, 0.87), Hungary (MI=0.59, 95% CI: 0.49, 0.69), and the Basque country in Spain (MI=0.86, 95% CI: 0.73, 0.99); but larger than 1 for Norway (MI=1.37, 95% CI: 1.20, 1.55). Unmarried Finnish, Hungarian, and Spanish (Basque country) men who were inactive in the labor market were actually better off than would be expected, based on the independent relative effects of labor force inactivity and being unmarried; while unmarried Norwegian men who were inactive in the labor force were worse off than would be expected.

The MI was found to be non-significant for black women; and women in Hungary, and England and Wales. For women, the estimated MIs for the other countries were positive, and ranged from 1.19 (Finland, 95% CI: 1.05, 1.34) to 1.58 (Basque country in Spain, 95% CI: 1.22, 1.93). These positive MIs indicated that unmarried women who were inactive in the labor force were worse off than would be expected, based on the independent relative effects of being unmarried or inactive alone. In other words, being inactive in the labor market was associated with higher mortality compared to being active, but this association was stronger for unmarried people than for those who were married. Likewise, being unmarried was associated with higher mortality, but this association was stronger for those who were inactive in the labor market

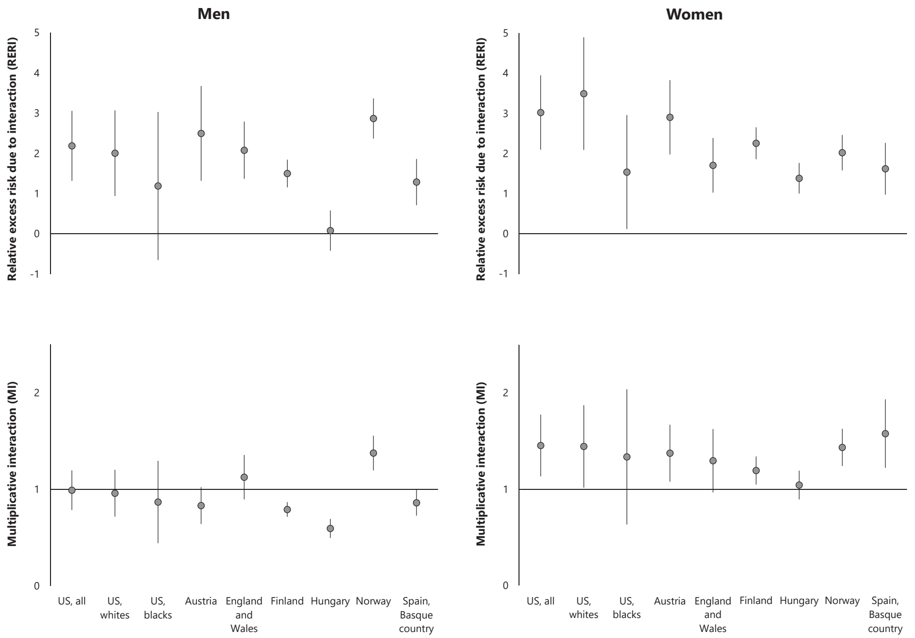

FIGURE 1 – **Measures of additive and multiplicative interaction for men and women aged 30–59 years, in seven countries**

Notes. RERIs and MIs are obtained from Poisson regression adjusted for age and education. Confidence intervals of both RERI and MI for the European countries were calculated by a bootstrap with 10,000 repetitions. $RERI=RR_{unmarried,inactive}-RR_{married,inactive}-RR_{unmarried,active}+1$; $MI=RR_{unmarried,inactive}/(RR_{married,inactive}\times RR_{unmarried,active})$. All rate ratios were calculated with the group married and active in the labor force as reference.

DISCUSSION

Summary of findings

Labor force inactivity was associated with higher mortality, but this association was stronger for unmarried than for married individuals. Likewise, being unmarried was associated with higher mortality, but this association was stronger for inactive, than for active, individuals. Among women, we found significant interactions on the additive and multiplicative scale between marriage and labor force activity on mortality. For men, there was also evidence of an interaction on the additive scale, but not on the multiplicative scale. Similar results were observed across the US and most European countries.

Interpretation

Our results supported the hypothesis that marriage attenuates the mortality risk associated with labor force inactivity, while labor force activity attenuates the mortality risk associated with being unmarried. We also found that the independent effects of labor force activity and marriage were stronger for men than for women; yet the interaction was found to be stronger for women, suggesting that the mortality risk associated with the combined exposure is larger for women than for men

The effect of combining work and marriage (or the lack of both) might be different for men and women, due to the traditional division of roles in the household. Men are typically less involved in household work.[25] For working men, marriage may be a source of both emotional and instrumental support. Compared to men who are both married and employed, unmarried and inactive men may be at a particular health disadvantage, as they lack these sources of support from both work and marriage. By contrast, although women may also benefit from combining work and marriage, the combination of both roles may also bring additional stress; due to the larger share of household responsibilities taken up by women, as compared to men. As a result, while unmarried and inactive women may be worse off than their married and active counterparts, this difference may be larger for women, than for men. For example, women are more likely to cook and carry out household work, which may benefit men's health. Women, in contrast, may derive less health benefits from marriage, given that men are less likely to be involved in household tasks.[25] Finally, gender differences in the selection mechanisms leading to marriage and employment may also partly explain the different results for men and women. Gender role expectations imply that men are more often expected to be active in the labor market, suggesting that the group of inactive men may be a more selective group of unhealthy men, as compared to their female counterparts, for whom work inactivity might more often be a choice. Health selection effects would thus result in a stronger association between labor market inactivity and mortality for men than women.

The bidirectional causal mechanisms generating the associations between marital status, labor force activity, and mortality do need to be taken into account: poor health is likely to decrease the probability of marriage and labor force activity,[1,3,5,26] while at the same time, marriage and labor force activity may confer several benefits to health. A stronger health-related selection among men than women into either marriage or the labor force, could explain the higher risks of mortality for men.

Our results also indicated that these interactions do not play out differently across countries with different levels of generosity in social protection. While social safety nets are generally less generous in the US and Hungary, as compared to countries such as Norway, Austria, and Finland, the interactions of marriage and labor force activity on mortality were very similar across these countries. This suggests that the mechanisms generating an interaction between marriage and labor force inactivity may not be the direct product of social policy, but do largely reflect generic effects of both marriage and labor force activity that are operating at the individual level, regardless of the social policy context.

Methodological considerations

A major strength of this study was the inclusion of six European countries and the US. This allowed us to improve our understanding of the underlying mechanisms, by exploiting the potential variation generated by different social protection policies; however, several methodological problems need to be taken into account, in drawing conclusions from this study. First, our definition of marital status was broad. Legal marital status does not distinguish, for example, unmarried individuals who are cohabiting; however, it is known that cohabitating individuals do have higher mortality than married individuals, but lower mortality than unmarried individuals living alone.[27] Therefore, we are likely to have underestimated the risk of dying for unmarried persons. To the extent that cohabitation is more prevalent in some of the Nordic European countries,[28] this may have influenced our cross-national comparisons.

Another limitation refers to the fact that the US NHIS does not include persons living in institutions, while the European samples cover their whole populations (some exceptions can be found in Table A); however, their survival rates, as observed in the NHIS mortality follow-up data, do closely resemble those of the general US population.[29] Because only a small proportion of the US population aged between 30 and 59 years is institutionalized (about 1%), the exclusion of persons living in institutions from the US sample was unlikely to alter the pattern observed for this country.

Third, we collapsed the employed and unemployed in the category 'active in the labor force'. This is the typical approach to define labor market activity; however, it may be argued that unemployed individuals should be classified as inactive in the labor market, especially if they are in long-term unemployment. We explored the impact of this decision on our results by running supplementary models with an alternative definition that combines the unemployed category with the category of persons who are out of the labor force. This was possible for Italy, Spain, Sweden, and Switzerland. These analyses, summarized in Tables C–F and Figure A (available in the supplemental materials), suggested that differences in the classification have very limited impact on the estimates, which resemble those from our primary models. Moreover, a comparison of the results from both definitions based on the US data also showed that our findings are robust against deviations from the original definition (Tables C–F and Figure A). Likewise, our definition of labor market inactivity was also broad: it combined homemakers with those still in the education system, the retired, and those with a work disability; however, because we focused on ages 30 to 59, we expected most of the latter groups to be very small, with most of the inactive individuals corresponding to homemakers.

Cross-national differences in methods of data collection, baseline periods, follow-up periods, and population covered might have affected our mortality estimates. In addition, other possibly interesting variables, such as prior health or type of employment contract, were not available in the data; and therefore, could not be included in our analysis. This implied that health-related selection cannot be discarded as one of the mechanisms explaining the associations we observed. Our study only included information on marital status and labor market activity at baseline. Individuals may have gotten married or divorced, and they may have lost their job or returned to the labor force after that baseline. We were not able to account for these changes, because labor force activity and marital status were only measured at a single point in time. In addition, we were not able to assess the impact of quality of work or relationship quality, which may be important moderations of the associations between marriage, work, and mortality. Future studies with more detailed data on these variables should be carried out.

Implications and conclusions

The increased risk of dying for individuals who are unmarried and inactive in the labor force implied that adequate interventions and policies for this segment of the population may be needed. For example, in the US, programs such as the Earned Income Tax Credit aim to improve the social and economic well-being of lone mothers who are out of the labor market, by introducing financial incentives to work. These programs have been shown to bring benefits to health.[30] Yet, the development of such actions requires a deeper understanding of the underlying mechanisms, for example based on studies including potentially mediating factors, and studies circumventing the problem of health selection. Nevertheless, our results support the hypothesis that marriage attenuates the mortality risk associated with labor force inactivity, while labor force activity attenuates the mortality risk associated with being unmarried.

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SUPPLEMENTAL MATERIALS

TABLE A – Overview of European and US data sets, 1999–2008

Country and region (if applicable)	Type of study	Baseline	Follow-up	Subjects, No.	Person-years, No.	Deaths, No.
In the main text						
United States	National, longitudinal, mortality study for a representative sample of the population	1999–2003	2004–2008	431,659	1,623,903	14,069
Austria	National, longitudinal, census-linked mortality study	2001	2002	3,490,938	3,486,305	9332
England and Wales	National, longitudinal, census-linked mortality study for a representative sample of 1 percent of the population	2001	2006	224,917	1,056,467	2694
Finland	National, longitudinal, census-linked mortality study with 20 percent of the population randomly excluded	2001	2007	NA[a]	11,413,193	40,871
Hungary	National, cross-sectional unlinked, census-linked mortality study	1999	2002	4,156,918	16,627,672	107,839
Norway	National, longitudinal, census-linked mortality study	2001	2006	1,852,720	9,205,357	24,566
Spain, Basque country	Regional, longitudinal, census-linked mortality study	2001	2006	920,868	4,711,241	10,974
In the supplemental materials						
United States	National, longitudinal, mortality study for a representative sample of the population	1999–2003	2004–2008	431,659	1,623,903	14,069
Italy, Turin	City of Turin, longitudinal, census-linked mortality study	2001	2006	359,703	1,608,054	3493
Italy, Tuscany	Regional, longitudinal, census-linked mortality study	2001	2005	252,675	972,351	1959
Spain, Madrid	Regional, cross-sectional linked, census-linked mortality study	2001	2003	2,304,964	3,841,653	9146
Sweden	National, longitudinal, census-linked mortality study	2001	2006	3,623,647	21,467,805	59,935
Switzerland[b]	National, longitudinal, census-linked mortality study	2001	2005	2,425,437	12,059,133	28,252

Notes. [a] The Finnish data did not include information on the number of subjects. [b] Non-Swiss nationals were excluded.

TABLE B – **Joint distribution of marital status and labor force activity for men and women aged 30–59 years, in seven countries**

	US, all	US, whites	US, blacks	Austria	England and Wales	Finland	Hungary	Norway	Spain, Basque country
Men, %									
Married and active	48	49	36	61	59	52	56	53	63
Unmarried and active	28	26	38	30	28	37	20	34	28
Married and inactive	14	15	10	5	7	5	15	5	6
Unmarried and inactive	10	9	16	4	6	7	9	8	4
Women, %									
Married and active	35	37	23	43	47	53	44	48	38
Unmarried and active	27	24	43	25	24	33	19	29	21
Married and inactive	22	23	10	25	19	8	25	13	35
Unmarried and inactive	17	16	24	7	10	6	12	10	7

TABLE C – Distribution, mortality rates, and rate ratios of marital status and labor force activity (unemployed grouped with non-employed individuals) for men aged 30–59 years in the United States and 4 European countries

	Unemployed grouped with employed individuals	Unemployed grouped with non-employed individuals					
	United States	United States	Italy, Turin	Italy, Tuscany	Spain, Madrid	Sweden	Switzerland
Percentage							
Married	62	62	65	69	72	51	69
Unmarried	38	38	35	31	28	49	31
Active	77	74	83	85	87	84	92
Inactive	23	26	17	15	13	16	8
Mortality rate per 100,000 person-years (95% CI)							
Married	314 (293, 335)	314 (293, 335)	213 (201, 225)	185 (172, 199)	295 (286, 305)	212 (209, 216)	245 (240, 250)
Unmarried	695 (643, 746)	695 (643, 746)	398 (371, 424)	380 (343, 418)	660 (631, 689)	486 (480, 493)	477 (465, 488)
Active	290 (271, 309)	285 (266, 304)	203 (192, 214)	175 (162, 188)	255 (246, 263)	222 (219, 225)	239 (235, 243)
Inactive	1211 (1103, 1319)	1079 (990, 1169)	528 (488, 568)	477 (427, 528)	945 (907, 983)	802 (789, 815)	888 (863, 913)
Total	413 (393, 434)	413 (293, 434)	264 (253, 275)	228 (215, 242)	363 (354, 372)	326 (323, 330)	304 (300, 309)
Rate ratio (95% CI)							
Unmarried versus married	2.21 (2.00, 2.45)	2.21 (2.00, 2.45)	1.87 (1.71, 2.04)	2.05 (1.81, 2.32)	2.23 (2.12, 2.36)	2.29 (2.24, 2.34)	1.94 (1.89, 2.01)
Inactive versus active	4.17 (3.70, 4.70)	3.79 (3.38, 4.24)	2.60 (2.37, 2.86)	2.72 (2.39, 3.10)	3.71 (3.52, 3.91)	3.61 (3.54, 3.69)	3.72 (3.59, 3.84)

Notes. CI: confidence interval. Mortality rates and rate ratios were obtained from Poisson regression models adjusted for age and education.

TABLE D – **Distribution, mortality rates and rate ratios of marital status and labor force activity (unemployed grouped with non-employed individuals) for women aged 30–59 years in the United States and 4 European countries**

	Unemployed grouped with employed individuals	Unemployed grouped with non-employed individuals					
	United States	United States	Italy, Turin	Italy, Tuscany	Spain, Madrid	Sweden	Switzerland
Percentage							
Married	56	56	67	70	70	56	70
Unmarried	44	44	33	30	30	44	30
Active	61	59	60	61	55	80	62
Inactive	39	41	40	39	45	20	38
Mortality rate per 100,000 person-years (95% CI)							
Married	208 (190, 226)	208 (190, 226)	131 (122, 140)	124 (113, 135)	131 (125, 137)	168 (164, 171)	144 (140, 147)
Unmarried	385 (352, 419)	385 (352, 419)	188 (171, 205)	220 (195, 245)	231 (217, 244)	281 (275, 286)	244 (236, 251)
Active	172 (156, 189)	171 (155, 187)	107 (98, 117)	113 (101, 125)	108 (101, 115)	155 (153, 158)	132 (128, 136)
Inactive	497 (452, 541)	477 (436, 519)	200 (185, 215)	194 (175, 213)	203 (193, 212)	421 (412, 430)	230 (224, 236)
Total	267 (250, 283)	267 (250, 283)	148 (139, 156)	148 (138, 159)	157 (152, 163)	212 (209, 215)	172 (168, 175)
Rate ratio (95% CI)							
Unmarried versus married	1.86 (1.64, 2.10)	1.86 (1.64, 2.10)	1.43 (1.28, 1.60)	1.78 (1.54, 2.06)	1.76 (1.63, 1.90)	1.67 (1.63, 1.72)	1.70 (1.63, 1.76)
Inactive versus active	2.88 (2.51, 3.30)	2.79 (2.44, 3.19)	1.86 (1.66, 2.10)	1.72 (1.48, 2.00)	1.87 (1.72, 2.04)	2.71 (2.64, 2.78)	1.74 (1.67, 1.81)

Notes. CI: confidence interval. Mortality rates and rate ratios were obtained from Poisson regression models adjusted for age and education.

TABLE E – **Mortality rates and rate ratios of marital status and labor force activity (unemployed grouped with non-employed individuals) for men and women aged 30–59 years in the United States and 4 European countries**

	Unemployed grouped with employed individuals	Unemployed grouped with non-employed individuals					
	United States	United States	Italy, Turin	Italy, Tuscany	Spain, Madrid	Sweden	Switzerland
Men							
Mortality rate per 100,000 person-years (95% CI)							
Married and active	243 (222, 263)	241 (221, 262)	178 (166, 190)	155 (141, 169)	224 (216, 233)	177 (173, 180)	210 (205, 215)
Unmarried and active	446 (401, 491)	797 (699, 896)	385 (345, 425)	345 (297, 394)	768 (726, 810)	459 (445, 474)	691 (661, 721)
Married and inactive	898 (782, 1014)	434 (388, 480)	273 (248, 299)	254 (220, 289)	412 (386, 437)	295 (289, 301)	335 (324, 345)
Unmarried and inactive	1632 (1450, 1814)	1465 (1312, 1618)	745 (672, 818)	731 (627, 835)	1271 (1196, 1347)	1046 (1027, 1064)	1118 (1077, 1159)
Total	413 (393, 434)	413 (293, 434)	264 (253, 275)	228 (215, 242)	363 (354, 372)	326 (323, 330)	304 (300, 309)
Rate ratio (95% CI)							
Married and active (Ref)	1	1	1	1	1	1	1
Unmarried and active	1.84 (1.61, 2.09)	3.30 (2.82, 3.87)	2.16 (1.91, 2.44)	2.23 (1.89, 2.62)	3.43 (3.21, 3.67)	2.60 (2.51, 2.70)	3.29 (3.14, 3.45)
Married and inactive	3.70 (3.13, 4.36)	1.80 (1.57, 2.05)	1.53 (1.37, 1.72)	1.64 (1.39, 1.93)	1.84 (1.71, 1.98)	1.67 (1.62, 1.72)	1.59 (1.53, 1.66)
Unmarried and inactive	6.72 (5.81, 7.78)	6.06 (5.27, 6.98)	4.18 (3.71, 4.71)	4.71 (3.98, 5.57)	5.67 (5.29, 6.09)	5.92 (5.76, 6.08)	5.32 (5.10, 5.56)
Women							
Mortality rate per 100,000 person-years (95% CI)							
Married and active	139 (122, 156)	139 (122, 156)	91 (81, 102)	94 (81, 108)	93 (85, 101)	136 (133, 139)	114 (110, 118)
Unmarried and active	232 (201, 263)	350 (311, 390)	176 (160, 191)	158 (139, 176)	160 (150, 169)	304 (294, 314)	178 (172, 184)
Married and inactive	359 (318, 400)	231 (200, 263)	138 (120, 156)	156 (130, 182)	137 (124, 149)	187 (183, 192)	165 (158, 172)
Unmarried and inactive	872 (759, 984)	794 (697, 892)	284 (247, 320)	338 (284, 392)	402 (371, 433)	554 (540, 568)	489 (467, 510)
Total	267 (250, 283)	267 (250, 283)	148 (139, 156)	148 (138, 159)	157 (152, 163)	212 (209, 215)	172 (168, 175)

TABLE E – **Mortality rates and rate ratios of marital status and labor force activity (unemployed grouped with non-employed individuals) for men and women aged 30–59 years in the United States and 4 European countries (continued)**

	Unemployed grouped with employed individuals	Unemployed grouped with non-employed individuals					
	United States	United States	Italy, Turin	Italy, Tuscany	Spain, Madrid	Sweden	Switzerland
Rate ratio (95% CI)							
Married and active (Ref)	1	1	1	1	1	1	1
Unmarried and active	1.67 (1.41, 1.98)	2.53 (2.15, 2.97)	1.93 (1.66, 2.23)	1.67 (1.39, 2.01)	1.72 (1.55, 1.92)	2.23 (2.14, 2.32)	1.56 (1.49, 1.64)
Married and inactive	2.58 (2.20, 3.04)	1.67 (1.40, 1.99)	1.51 (1.27, 1.79)	1.65 (1.33, 2.06)	1.48 (1.30, 1.67)	1.38 (1.33, 1.42)	1.44 (1.36, 1.53)
Unmarried and inactive	6.27 (5.21, 7.55)	5.74 (4.80, 6.86)	3.11 (2.61, 3.70)	3.58 (2.88, 4.44)	4.34 (3.86, 4.88)	4.06 (3.93, 4.21)	4.29 (4.04, 4.55)

Notes. CI: confidence interval; Ref: reference category. Mortality rates and rate ratios are obtained from Poisson regression models adjusted for age and education.

TABLE F – **Rate ratios of marital status within strata of labor force activity (unemployed grouped with non-employed individuals) and rate ratios of labor force activity (unemployed grouped with non-employed individuals) within strata of marital status for men and women aged 30–59 years in the United States and 4 European countries**

	Unemployed grouped with employed individuals	Unemployed grouped with non-employed individuals					
	United States	United States	Italy, Turin	Italy, Tuscany	Spain, Madrid	Sweden	Switzerland
Men							
Marital status							
Married							
Inactive versus active (95% CI)	3.56 (3.00, 4.21)	3.21 (2.73, 3.77)	2.06 (1.81, 2.35)	2.19 (1.85, 2.60)	3.33 (3.11, 3.56)	2.59 (2.49, 2.68)	3.24 (3.09, 3.40)
Unmarried							
Inactive versus active (95% CI)	3.80 (3.25, 4.45)	3.47 (2.97, 4.05)	2.79 (2.42, 3.20)	2.88 (2.35, 3.54)	3.11 (2.85, 3.39)	3.55 (3.45, 3.64)	3.39 (3.22, 3.56)
Labor force activity							
Active							
Unmarried versus married (95% CI)	1.86 (1.63, 2.11)	1.81 (1.58, 2.07)	1.59 (1.42, 1.79)	1.70 (1.44, 2.00)	1.90 (1.77, 2.05)	1.71 (1.66, 1.76)	1.61 (1.55, 1.68)
Inactive							
Unmarried versus married (95% CI)	1.78 (1.52, 2.10)	1.82 (1.56, 2.13)	1.67 (1.45, 1.93)	1.70 (1.38, 2.09)	1.50 (1.38, 1.63)	2.21 (2.13, 2.29)	1.55 (1.47, 1.64)
Women							
Marital status							
Married							
Inactive versus active (95% CI)	2.49 (2.10, 2.94)	2.45 (2.07, 2.90)	1.86 (1.60, 2.17)	1.63 (1.35, 1.98)	1.68 (1.50, 1.88)	2.25 (2.16, 2.34)	1.56 (1.49, 1.64)
Unmarried							
Inactive versus active (95% CI)	3.98 (3.28, 4.82)	3.57 (2.96, 4.30)	2.19 (1.80, 2.65)	2.26 (1.77, 2.88)	3.07 (2.71, 3.48)	2.93 (2.82, 3.04)	3.03 (2.85, 3.23)
Labor force activity							
Active							

TABLE F – **Rate ratios of marital status within strata of labor force activity (unemployed grouped with non-employed individuals) and rate ratios of labor force activity (unemployed grouped with non-employed individuals) within strata of marital status for men and women aged 30–59 years in the United States and 4 European countries (continued)**

	Unemployed grouped with employed individuals	Unemployed grouped with non-employed individuals					
	United States	United States	Italy, Turin	Italy, Tuscany	Spain, Madrid	Sweden	Switzerland
Unmarried versus married (95% CI)	1.64 (1.39, 1.95)	1.65 (1.38, 1.96)	1.51 (1.27, 1.79)	1.65 (1.32, 2.05)	1.47 (1.30, 1.67)	1.38 (1.33, 1.42)	1.44 (1.36, 1.53)
Inactive							
Unmarried versus married (95% CI)	2.47 (2.10, 2.91)	2.29 (1.95, 2.69)	1.61 (1.38, 1.87)	2.15 (1.77, 2.60)	2.52 (2.29, 2.77)	1.82 (1.75, 1.90)	2.75 (2.60, 2.90)

Notes. CI: confidence interval. Rate ratios are obtained from Poisson regression models adjusted for age and education.

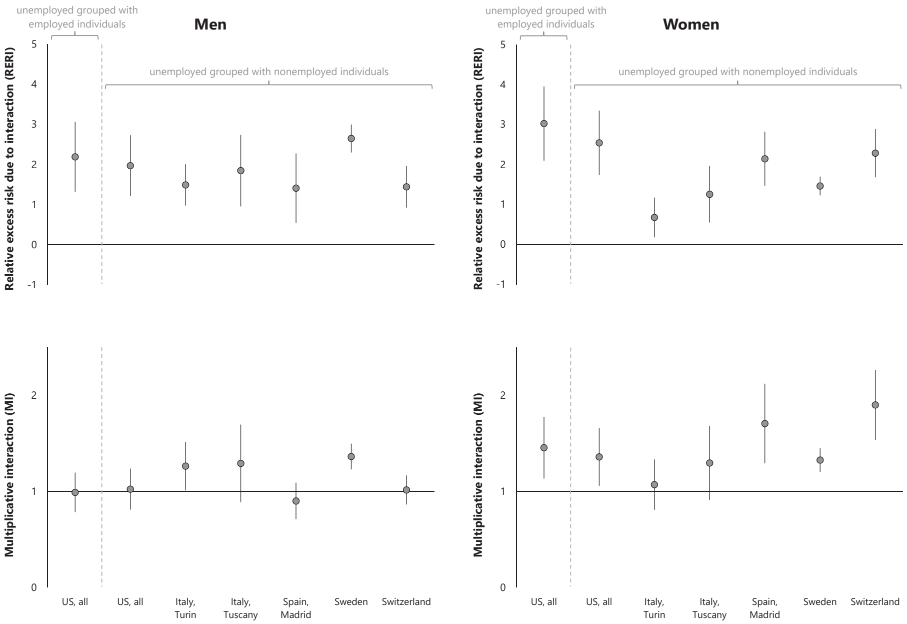

FIGURE A – **Measure of additive and multiplicative interaction for men and women aged 30–59 years in the United States and 4 European countries**

Notes. Left of the dotted lines represents the RERIs and MIs of the United States when the unemployed are grouped with employed individuals. The RERIs and MIs on the right side of the dotted lines are calculated by grouping the unemployed with non-employed individuals. RERIs and MIs are obtained from Poisson regression adjusted for age and education. Confidence intervals of both RERI and MI for the European countries are calculated by a bootstrap with 10,000 repetitions. $RERI=RR_{unmarried,inactive}-RR_{married,inactive}-RR_{unmarried,active}+1$; $MI=RR_{unmarried,inactive}/(RR_{married,inactive}\times RR_{unmarried,active})$. All rate ratios are calculated with the group married and active in the labor force as reference.

Chapter 6

Work-family trajectories and the higher cardiovascular risk of American women relative to women in 13 European countries

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ABSTRACT

Objectives. To investigate whether less-healthy work-family life histories contribute to the higher cardiovascular disease prevalence in older American compared with European women.

Methods. We used sequence analysis to identify distinct work-family typologies for women born between 1935 and 1956 in the United States and 13 European countries. Data came from the US Health and Retirement Study (1992–2006) and the Survey of Health, Aging, and Retirement in Europe (2004–2009).

Results. Work-family typologies were similarly distributed in the United States and Europe. Being a lone working mother predicted a higher risk of heart disease, stroke, and smoking among American women, and smoking for European women. Lone working motherhood was more common and had a marginally stronger association with stroke in the United States than in Europe. Simulations indicated that the higher stroke risk among American women would only be marginally reduced if American women had experienced the same work-family trajectories as European women.

Conclusions. Combining work and lone motherhood was more common in the United States, but differences in work-family trajectories explained only a small fraction of the higher cardiovascular risk of American relative to European women.

INTRODUCTION

Life expectancy is shorter in the United States than in many Western European countries. Older Americans are also more likely to report poorer health and to suffer chronic conditions, particularly American women.[1,2] Explanations for this so-called US health disadvantage include differences in the prevalence of smoking and other behavioral risk factors, rates of disease and injury, financial barriers to health care access, and psychosocial stress.[2–6] Although higher smoking prevalence histories among older women in the United States is one of the driving explanations,[3] none of these factors fully accounts for the female US health disadvantage.

Lives of American women changed substantially in the second half of the previous century. Female labor force participation increased more in the United States than in many European countries,[7] and marriage rates decreased more rapidly for US women as a result of a higher fraction of American women never marrying as well as higher divorce rates.[8,9] By contrast, although fertility rates declined in all countries,[10] they declined less in the United States than in many European countries, leaving more American women facing the prospect of combining work and family roles, often in the context of lone motherhood.

Women who are married, employed, and have children are generally healthier than their unmarried, non-employed, and childless counterparts.[11,12] Whereas the role accumulation theory suggests that combining family and work roles is beneficial for women's health, the multiple role theory poses that combining these roles may increase levels of stress, which has a negative impact on health.[13] These negative impacts may, however, depend on the availability of supportive policies that enable parents to combine work with family roles.

We hypothesized that work-family trajectories may be differentially related to cardiovascular health in the United States than in Europe, as a result of the different work-family policy environment in the United States and Europe. If combining family and work roles is beneficial for a woman's health, women experiencing a more family-friendly policy environment such as that in Europe may benefit more from role accumulation, resulting in better cardiovascular health. If combining roles is detrimental for a woman's health, American women may experience more strain from work-family stress than European women as a result of a less supportive policy environment in the United States.

The aim of this study was to assess whether less-healthy work-family life histories among American women have contributed to their cardiovascular health disadvantage in older age relative to women in 13 European countries. We used unique retrospective data for 13 European countries and the United States to construct full life histories and work-family trajectories, and linked them to stroke and heart disease outcomes in older ages. We examined the association between work-family trajectories and late-life cardiovascular outcomes and assessed whether the distribution and risks associated with these work-family trajectories explain why older American women have higher stroke and heart disease prevalence than older women in Europe.

METHODS

We used data from the Survey of Health, Aging, and Retirement in Europe (SHARE) for 13 European countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Italy, Netherlands, Poland, Spain, Sweden, and Switzerland). SHARE is a longitudinal biennial survey designed to provide insight into the lives of Europeans aged 50 years and older and their spouses.[14] For SHARE, representative samples of non-institutionalized adults aged 50 years and older in each European country were selected and interviewed in the household. The SHARE survey included approximately 30,000 respondents at each wave. The third wave of SHARE (2008–2009, "SHARELIFE") was specifically designed to gather information on retrospective life histories.[15] We used these data to construct marriage, employment, and maternal histories over the life course and to derivate work-family trajectories for each individual.[16] Complete work-family trajectories were available for 14,545 European women. We restricted our sample to women born between 1935 and 1956 (n=10,569 women). We linked the work-family typologies of these women to self-reported data on chronic diseases and risk factors measured in 2006 (n=9456), and to data on their educational attainment from either the 2004 or the 2006 wave of SHARE (n=9047). Because educational attainment was only asked during the baseline interview, we used educational information from the 2004 wave for those women who also participated in the earlier wave. Information on age and country of residence was available for all remaining women in our sample.

For the United States, we used data from the Health and Retirement Study (HRS), a longitudinal biennial survey of American adults aged 50 years and older.[17] The HRS incorporated a representative sample of the non-institutionalized population aged 50 years and older, and it included approximately 20,000 respondents every 2 years. We reconstructed marital, employment, and maternal histories by using retrospective reports collected at the baseline HRS interview. We then complemented these histories with the respondent's self-reports from successive waves of HRS from 1992 to 2006. In total, complete life histories were available for 7681 American women born between 1935 and 1956. We then linked the work-family typologies to chronic diseases and risk factors measured in the HRS interview in 2006, leaving 5985 women. To avoid that our US results would be driven by racial disparities in cardiovascular risk factors and chronic diseases,[18,19] we controlled for race (non-Hispanic whites, non-Hispanic blacks, and other races).

We categorized educational attainment by using the International Standard Classification of Education (ISCED)[20] scale into 4 levels: ISCED levels 0 and 1 (less than high school), ISCED level 2 (high school or equivalent), ISCED levels 3 and 4 (some college), and ISCED levels 5 and 6 (college or above). The distribution of educational attainment in the US and European sample can be found in Table A (available in the supplemental materials).

We defined work-family trajectories on the basis of 3 dimensions: marriage, employment, and child histories. Participants were asked about starting and ending dates of all marriages and of jobs, and birth dates of children. Questions were similar for the American and European samples. We used binary variables to keep the maximum number of combinations manageable. We defined employment status as having a paid job, maternity status as having at least 1 child younger than 18 years, and marital status as being married versus non-married (widowed, divorced, and never married).

We focused on 2 major chronic diseases shown to be more prevalent in the United States than in European countries: heart disease and stroke.[21] Participants were asked whether they had received a doctor's diagnosis for any of these conditions. We also incorporated diagnosed high blood pressure, whether individuals had ever smoked, and body mass index (BMI) based on self-reported weight in kilograms divided by height in meters squared. A respondent was classified as being obese if her BMI was 30 or higher. The mean and range of BMI for both samples can be found in Table A. The exact questions asked to the European and American respondents are presented in Table B (available in the supplemental materials).

Sequence analysis

To identify common work-family typologies in our data, we used sequence analysis, an approach that enabled us to identify work-family typologies derived from full work-family histories.[22] For each woman, we determined the work-family situation on the basis of 8 possible combinations of employment status (working for pay: yes or no), marital status (married: yes or no), and maternal status (at least 1 child younger than 18 years: yes or no) at each age between 16 and 50 years. This means that, for each woman, and on the basis of retrospective reports, we assigned a work-family combination for each year of life between the ages of 16 and 50 years. The analysis then used the timing and duration of each work-family combination to derive common trajectories. A detailed description of sequence analysis is included in Text A (available in the supplemental materials). An application of sequence analysis in a similar context is also available elsewhere.[23]

For the analysis, we pooled US and European data. In total, we found 15,542 distinct life trajectories for the 18,250 women in our sample. To define the optimal number of typologies, we used different cluster cut-off criteria, including the Point Biserial Correlation and the Calinski–Harabasz index (Table C, available in the supplemental materials).[24] On the basis of these criteria, we established that both 5 and 6 typologies best suited the data. The 5 typologies solution provided more (sociologically) meaningful and argumentative typologies; the 6 typologies solution had an unclear and less argumentative pattern (Figure A, available in the supplemental materials). We therefore focused our main interpretation on the 5 typologies solution. We conducted the sequence analysis by using the TraMineR and Weighted Cluster packages in R version 3.2.1 (R Foundation for Statistical Computing, Vienna, Austria).[24,25]

Statistical analysis

We used logistic regression to estimate the difference in cardiovascular disease and risk factors of American compared with European women. We examined whether the distribution of the work-family typologies differed between American and European women. We used logistic regression to model cardiovascular diseases and risk factors as a function of work-family typology with control for race in the United States, age (indicated by 5-year age intervals), educational attainment, whether women resided in the United States or Europe, and European country of residence. To assess whether associations between work-family typology and cardiovascular outcomes differed between the United States and Europe, we used a Wald test for the interaction between work-family typology and region of residence. To assess the contribution of work-family typology to chronic disease and risk factors between the United States and Europe, we combined estimates from the logistic models with the observed distribution of women over the typologies in the United States and Europe. This enabled us to obtain the probabilities of each outcome for US women, under the counterfactual scenario that they had been exposed to the same distribution of and cardiovascular risk associated with each typology as European women. A detailed description of this approach is included in Text B (available in the supplemental materials). We have applied this approach before.[26]

We conducted all statistical analyses with Stata SE version 13 (StataCorp LP, College Station, TX).

RESULTS

American women had poorer cardiovascular health and less-healthy risk-factor profiles than women in Europe (Figure 1), as indicated by an increased odds for all outcomes, particularly for having had a diagnosis of heart disease (odds ratio [OR]=2.74; 95% confidence interval [CI]: 2.43, 3.10) or stroke (OR=2.21; 95% CI: 1.75, 2.79).

Work-family typologies over the life course

The most common work-family typology comprised married mothers who returned to work after a few years of non-employment (28%), and the least common typology comprised working single mothers (8%; Figure 2). In both the United States and Europe, about 10% of women were single working childless women (typology 1, 10% in the United States, 11% in Europe). Twenty-five percent of American women were stay-home married mothers (typology 2), compared with 29% of European women. A larger proportion of American

(11%) than European (5%) women was classified as working single mothers (typology 3). More American (31%) than European women (25%) were married mothers that returned to work after a few years of non-employment (typology 4). More European (29%) than American (23%) women were working married mothers (typology 5). Distributions of age, educational attainment, and reported cardiovascular risk factors and chronic diseases by typology are presented in Table D (available in the supplemental materials).

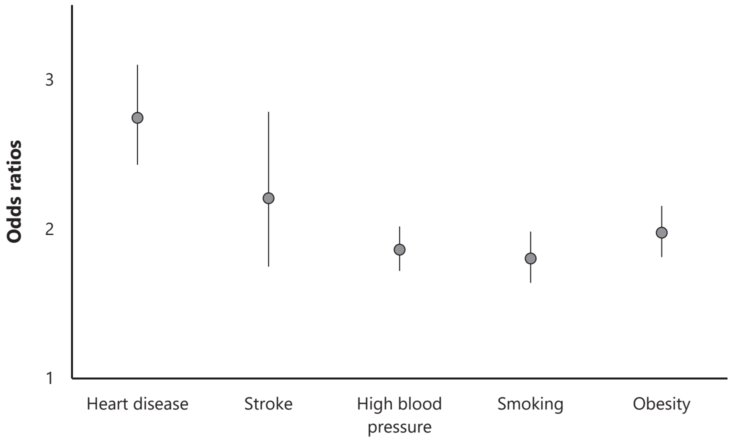

FIGURE 1 – Odds ratios of heart disease, stroke, high blood pressure, smoking, and obesity for American women compared with European women, aged 50–72 years
Note. Models controlled for race (United States only), age, and education.

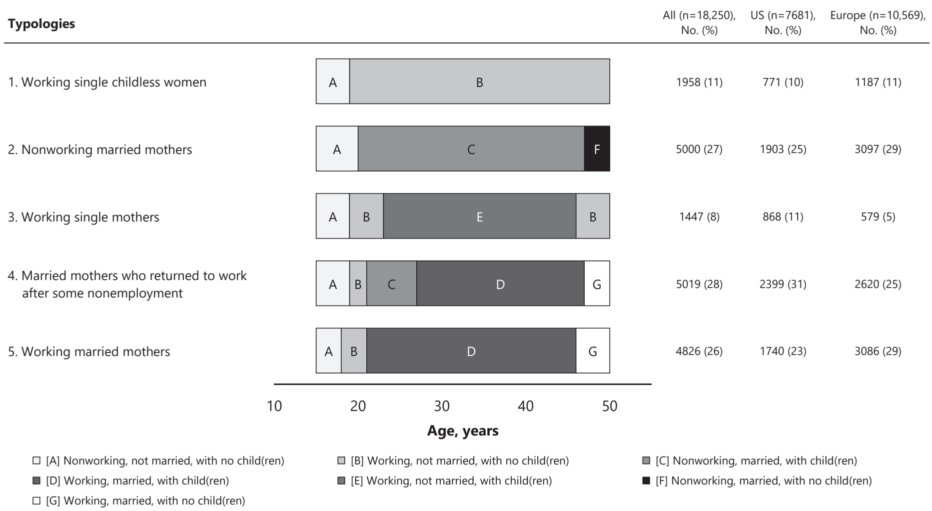

FIGURE 2 – Work-family typologies between the ages of 16 and 50 years for US and European women aged 50–72 year

Cardiovascular disease and risk factors

Working single childless women had lower odds of having high blood pressure than working married mothers (Table 1; OR=0.84; 95% CI: 0.74, 0.96). Compared with working married mothers, nonworking married mothers had significantly lower odds of having ever smoked (OR=0.85; 95% CI: 0.76, 0.96), but higher odds of being obese (OR=1.12; 95% CI: 1.01, 1.25). Working single mothers had higher odds of heart disease (OR=1.40; 95% CI: 1.14, 1.71), stroke (OR=1.74; 95% CI: 1.22, 2.47), and smoking (OR=1.77; 95% CI: 1.50, 2.09). Married mothers who left work and subsequently returned to work after a few years had higher odds of stroke (OR=1.35; 95% CI: 1.03, 1.77) compared with working married mothers.

There was no consistent pattern suggesting that certain typologies were systematically more harmful for American than European women. In Europe, working single childless women were less likely to have high blood pressure (OR=0.78; 95% CI: 0.66, 0.92) but more likely to have smoked (OR=1.37; 95% CI: 1.07, 1.75) than working married mothers. These associations were not significant in the United States (OR=0.94; 95% CI: 0.77, 1.15 and OR=1.11; 95% CI: 0.91, 1.35 for high blood pressure and smoking, respectively). The odds of stroke among working single mothers compared with married working mothers were higher in the United States (OR=2.09; 95% CI: 1.36, 1.64) than in Europe (OR=0.88; 95% CI: 0.39, 1.97). The odds for smoking among working single mothers compared with married working mothers were higher in Europe (OR=2.20; 95% CI: 1.62, 2.99) than in the United States (OR=1.67; 95% CI: 1.38, 2.03). Although some typologies were associated with cardiovascular risk factors and chronic diseases within Europe and the United States, no statistically significant differences were found in the odds of any of the cardiovascular risk factors and chronic diseases between American and European women in all work-family typologies.

US-Europe differences in cardiovascular health

Table 2 shows the observed probabilities of each cardiovascular outcome, alongside the counterfactual probabilities if US women had experienced the same distribution of and risks associated with work-family typologies as European women. American women would have had a marginal lower probability of chronic diseases and risk factors except for obesity if they had been exposed to the same distribution of work-family typologies as European women. For example, the original probability of stroke for US women was 4.4% (95% CI: 3.9%, 4.9%); however, if US women would experience the same work-family typology distribution as European women, their counterfactual probability would be 4.1% (95% CI: 3.6%, 4.6%). These decreases in the probabilities for US women reflected the fact that European women had slightly "healthier" work-family typologies (e.g., working married mothers) and fewer were working single mothers than were American women. If US women would have had the same health risks associated with each work-family typology as European women,

TABLE 1 – **Odds ratios of combinations of work, marital status, and having children on chronic diseases and risk factors for women aged 50–72 years in the pooled data and separately for the United States and Europe**

Chronic diseases and risk factors	Sample size, No.	Typology 1: Working single childless women, OR (95% CI)	*P*	Typology 2: Nonworking married mothers, OR (95% CI)	*P*	Typology 3: Working single mothers, OR (95% CI)	*P*	Typology 4: Married mothers who returned to work after some non-employment, OR (95% CI)	*P*	Typology 5: Working married mothers, OR (Ref)
Heart disease			0.48		0.82		0.87		0.07	
Pooled	15,026	1.04 (0.84, 1.28)		0.98 (0.84, 1.15)		1.40 (1.14, 1.71)		1.05 (0.91, 1.21)		1
US	5979	0.96 (0.72, 1.27)		0.96 (0.79, 1.18)		1.34 (1.05, 1.70)		0.94 (0.78, 1.14)		1
Europe	9047	1.11 (0.82, 1.52)		1.00 (0.78, 1.28)		1.39 (0.95, 2.02)		1.24 (0.99, 1.55)		1
Stroke			0.24		0.57		0.06		0.95	
Pooled	15,028	1.23 (0.83, 1.83)		1.01 (0.75, 1.38)		1.74 (1.22, 2.47)		1.35 (1.03, 1.77)		1
US	5981	1.53 (0.91, 2.57)		1.09 (0.72, 1.64)		2.09 (1.36, 3.21)		1.38 (0.96, 2.00)		1
Europe	9047	0.94 (0.51, 1.73)		0.90 (0.56, 1.46)		0.88 (0.39, 1.97)		1.36 (0.91, 2.03)		1
High blood pressure			0.17		0.45		0.96		0.14	
Pooled	15,027	0.84 (0.74, 0.96)		1.05 (0.95, 1.16)		0.96 (0.83, 1.12)		1.05 (0.96, 1.15)		1
US	5980	0.94 (0.77, 1.15)		1.10 (0.93, 1.28)		0.98 (0.80, 1.20)		1.14 (0.99, 1.31)		1
Europe	9047	0.78 (0.66, 0.92)		1.01 (0.89, 1.15)		0.97 (0.78, 1.21)		0.99 (0.87, 1.12)		1
Smoking			0.20		0.90		0.14		0.73	
Pooled	9806	1.12 (0.97, 1.31)		0.85 (0.76, 0.96)		1.77 (1.50, 2.09)		1.08 (0.97, 1.21)		1
US	5984	1.11 (0.91, 1.35)		0.85 (0.73, 0.99)		1.67 (1.38, 2.03)		1.08 (0.94, 1.24)		1
Europe	3822	1.37 (1.07, 1.75)		0.87 (0.70, 1.07)		2.20 (1.62, 2.99)		1.12 (0.94, 1.34)		1
Obesity			0.13		0.39		0.37		0.13	
Pooled	14,915	0.99 (0.86, 1.14)		1.12 (1.01, 1.25)		1.06 (0.91, 1.24)		1.03 (0.93, 1.14)		1
US	5984	1.08 (0.88, 1.33)		1.17 (1.00, 1.37)		1.01 (0.83, 1.23)		0.95 (0.82, 1.09)		1
Europe	8931	0.87 (0.71, 1.06)		1.06 (0.92, 1.24)		1.17 (0.91, 1.49)		1.11 (0.96, 1.28)		1

Notes. CI: confidence interval; OR: odds ratio; Ref: reference category. The analyses controlled for race (United States only), age, education, and country of residence. The *p* value of the Wald test shows whether the estimated odds ratio for the United States differs significantly from the estimated odds ratio in Europe. *P* values of the Wald test of less than .05 show significant differences.

the probability for stroke and high blood pressure would decrease, but the probability for heart disease, smoking, and obesity would increase. When we combine all information, results show that American women would have had a marginally lower probability of stroke and high blood pressure if they had been exposed to both the European distribution as well as the European health risks associated with each typology. The reduction in the probability of high blood pressure would be around 2 percentage points (from 53.3% to 51.4%), and the reduction in the probability of stroke would be about 1 percentage point (from 4.4%

TABLE 2 – **Counterfactual probability of chronic diseases and risk factors for US women aged 50–72 years if they would have had the same distribution of and health risks associated with each work-family typology as European women**

Variable	Heart disease, probability (95% CI)	Stroke, probability (95% CI)	High blood pressure, probability (95% CI)	Smoking, probability (95% CI)	Obesity, probability (95% CI)
Observed original probabilities					
US women[a]	0.172 (0.162, 0.181)	0.044 (0.039, 0,049)	0.533 (0.521, 0.546)	0.511 (0.498, 0.523)	0.371 (0.358, 0.383)
European women[b]	0.068 (0.063, 0.074)	0.018 (0.015, 0.021)	0.324 (0.314, 0.334)	0.403 (0.387, 0.418)	0.211 (0.203, 0.220)
Difference between the US and Europe[c]	0.103 (–0.067, 0.273)	0.026 (–0.099, 0.151)	0.209 (0.000, 0.418)	0.108 (–0.127, 0.343)	0.159 (–0.042, 0.361)
US counterfactual probabilities if European work-family typology distributions					
US counterfactual probability[d]	0.169 (0.160, 0.179)	0.041 (0.036, 0.046)	0.531 (0.519, 0.545)	0.503 (0.490, 0.515)	0.374 (0.361, 0.386)
Difference with original US probability[e]	–0.002 (–0.196, 0.191)	–0.003 (–0.144, 0.139)	–0.001 (–0.224, 0.221)	–0.008 (–0.231, 0.215)	0.003 (–0.216, 0.222)
Difference with European probability[f]	0.101 (–0.069, 0.271)	0.023 (–0.100, 0.147)	0.208 (–0.001, 0.417)	0.100 (–0.135, 0.335)	0.162 (–0.039, 0.364)
US counterfactual probabilities if European health risks associated with each work-family typology					
US counterfactual probability[g]	0.188 (0.179, 0.198)	0.036 (0.032, 0.041)	0.514 (0.501, 0.527)	0.526 (0.514, 0.539)	0.376 (0.364, 0.389)
Difference with original US probability[e]	0.017 (–0.179, 0.212)	–0.008 (–0.147, 0.132)	–0.019 (–0.242, 0.203)	0.016 (–0.207, 0.238)	0.006 (–0.213, 0.225)
Difference with European probability[f]	0.120 (–0.052, 0.292)	0.018 (–0.103, 0.139)	0.190 (–0.019, 0.399)	0.124 (–0.111, 0.359)	0.165 (–0.037, 0.366)
US counterfactual probabilities if European work-family typology distributions and European health risks associated with each typology					
US counterfactual probability[h]	0.183 (0.173, 0.193)	0.035 (0.031, 0.040)	0.514 (0.501, 0.526)	0.515 (0.502, 0.527)	0.373 (0.360, 0.385)
Difference with original US probability[e]	0.012 (–0.183, 0.206)	–0.008 (–0.148, 0.131)	–0.020 (–0.242, 0.203)	0.004 (–0.207, 0.238)	0.002 (–0.217, 0.221)
Difference with European probability[f]	0.115 (–0.057, 0.286)	0.017 (–0.103, 0.138)	0.190 (–0.020, 0.399)	0.112 (–0.123, 0.347)	0.161 (–0.040, 0.363)

Notes. CI: confidence interval. The analyses controlled for race (United States only), age, education, and country of residence. [a] The probability of risk factors and chronic diseases for US women. [b] The probability of risk factors and chronic diseases for European women. [c] The difference in probability for US and European women. [d] The probability of risk factors and chronic diseases for US women if the distribution of work-family typologies in the United States was substituted by the European distribution. [e] The difference between the original probability for US women and the estimated one. [f] The difference between the estimated probability for US women and the original probability for European women. [g] The probability of risk factors and chronic diseases for US women if the odds ratios related to the work-family typologies in the United States were substituted by those seen in Europe. [h] The probability of risk factors and chronic diseases for US women if the distribution of work-family typologies in the United States and the odds ratios related to the work-family typologies in the United States were substituted by those seen in Europe.

to 3.5%). These findings suggest that differences in work-family typologies explained only a small fraction of the higher prevalence of cardiovascular disease of American relative to European women.

DISCUSSION

Overall, distributions of work-family typologies and their associated cardiovascular health risks were relatively similar between the United States and Europe. American women were more likely to have had a history of working single motherhood than European women. Single working motherhood was consistently associated with worse cardiovascular health outcomes, but we found no evidence that this association was stronger for American than for European women. This larger probability of stroke among American women, however, would only be marginally reduced if American women had experienced similar work-family trajectories and risks as European women. Our findings suggest that work-family typologies contributed little to the higher prevalence of cardiovascular disease and risk factors of American relative to European women.

Methodological considerations

We pooled data to derive work-family typologies to ensure that both American and European women were clustered in the same way. In sensitivity analysis, we conducted sequence analyses for women in the US and Europe separately (results available upon request), but this revealed no substantial differences in typologies between the United States and Europe. The only exception was for single working mothers, whereby US women were often clustered in a new typology of working married mothers who became divorced or widowed. Some of the differences in risk associated with this typology may thus reflect the fact that we were comparing two partly different groups of women in the United States and Europe.

Sequence analysis requires complete life trajectories. We used partial imputations and made some assumptions on the basis of the retrospective data when information was incomplete. For SHARE, we assumed no gap between 2 spells of employment if information was incomplete.[27] For HRS, we inferred information on work and family life from information on children's birth dates, wedding and divorce dates, and starting and ending dates of jobs.[23] If these inferences were insufficient, we applied partial imputations to minimize the amount of missing data; this was true for about 3% of marriage histories, about 24% of work histories, and 0% of parental histories. For HRS, we validated work history imputations by using Social Security data. These Social Security records were available from 1951 onward. Women born in 1935 would have been aged 16 years in 1951, which is the first age of our work-life trajectory, and therefore we only included women born in 1935 or later in our sample. This resulted in women aged 50 to 72 years being selected for all samples.

When defining the work-family variables, we decided to use dichotomized variables to represent whether each woman was an employee, a wife, or a mother. It could be argued that our analysis might have benefitted from more detailed information on employment, marital status, and child histories. In particular, employed women might have been working part-time or full-time, non-employment may have been a choice, women who were not married might have been cohabitating or may have had strong support from family or friends, and mothers might have had 1 or more children. However, this additional information would also increase the number of manageable work-family combinations, potentially compromising comparability across regions. For this analysis, we felt that a dichotomous version of exposure variables was appropriate to provide a sense of the overall contribution of work-family typologies to health differences between American and European women.

We used self-reported measures of cardiovascular disease because no objective measures of cardiovascular disease endpoints were available in HRS and SHARE. However, Banks et al.[1] have shown large consistency between data from biomarkers and self-reports with data from HRS (United States) and the English Longitudinal Study of Aging (England). In addition, Glymour and Avendano[28] found that incidence rates of stroke based on self-reports in HRS compare well to stroke incidence estimates from clinically verified studies. Therefore, although we acknowledge this limitation, we believe self-reported data provide an overall good estimate of the prevalence of broad categories of cardiovascular disease in a population. Another possible limitation of our measures is that both heart disease and stroke comprise broad categories of cardiovascular disease, so that we are unable to derive conclusions on the prevalence of subtypes of cardiovascular disease. In addition, differences in how the risk factors and chronic diseases were measured in HRS and SHARE (Table B) remain a potential source of bias. However, it is unclear whether this discrepancy would change the general conclusion regarding the association between work-family typologies and the cardiovascular outcomes, particularly smoking.

Interpretation

Consistent with findings from previous studies, we found that women who were consistently working, married, and had children were in general healthier than women following a different work-family life trajectory.[23,29] This is consistent with the role accumulation hypothesis, which suggests that combining these roles is beneficial for a woman's health.[13] As an alternative, however, this finding is likely to reflect at least some selection: healthier women are more likely to marry, have children, and work. We also found that married mothers who returned to paid employment after some years of non-employment had elevated odds of stroke and that working single mothers were worse off than working married mothers. This suggests that combining work and parenthood while having little (spousal) support may be detrimental for a woman's cardiovascular health in the long run.[30]

Lone motherhood was more common in the United States than in Europe and was more strongly related to stroke among American women. Lone mothers are at higher risk of poverty and unemployment.[31,32] Therefore, more generous family policies in Europe may relieve poverty and related stress, for example, by providing maternity leave, offering the possibility to work part-time, and providing better child care and support.[33] As a result, single working mothers in the United States may have had more often difficulties to make ends meet, and they may have experienced more stressful lives than European mothers under more supportive policy regimes. Single nonworking mothers in the United States who lacked (employment-related) health insurance may have experienced larger inequalities in health care access than European mothers because health care is more universally accessible in Europe than the United States.[34]

The prevalence of lone motherhood increased in recent decades in both Europe and the United States.[35] Our findings, therefore, highlight the need to develop wider policies to support single mothers in both regions. First, policies that target cardiovascular disease prevention to single working mothers may prove important to obtain gains in population health. Second, programs that support poor working single mothers such as the Earned Income Tax Credit or child allowances for working parents may contribute to reducing their health disadvantage.

Overall, we found only small differences in the composition of and cardiovascular risks associated with work-family typologies over the lifetime of American and European women. This suggests that the dominant mechanisms linking work, marital, and maternal status (including financial security and social support) to cardiovascular risk, and the buffering role of social policies for women in these typologies, are relatively similar and do not result in different associations with cardiovascular outcomes. Instead, other factors may explain the higher prevalence of cardiovascular disease among US women. For example, smoking, obesity, and other proximal risk factors have been put forward in the literature as partial explanations for the US female health disadvantage.[2–6] Also, larger educational disparities in mortality in the United States than in Europe partly explain why mortality in the United States is higher than that in many European countries.[26] Overall, we found that differences in work-family typologies explained only a small fraction of the excess risk of stroke and high blood pressure of American women compared with European women.

Conclusions and implications

Working single motherhood was more common in the United States than in Europe, but differences in work-family trajectories explained only a small fraction of the excess cardiovascular risk of American relative to European women. Policies and interventions that support women combining work and family roles may improve women's cardiovascular health, but may only marginally contribute to reducing the health disadvantage of American compared with European women. Further research should examine whether other aspects of women's life trajectories may be more important in understanding the health disadvantage of American relative to European women.

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SUPPLEMENTAL MATERIALS

TABLE A – Distribution of educational attainment, and mean and ranges of body mass index (BMI) for both samples

	United States	Europe
Educational level, No. (%)		
ISCED levels 0 and 1; less than high school	1579 (21)	2481 (25)
ISCED level 2; high school or equivalent	2884 (38)	1941 (20)
ISCED levels 3 and 4; some college	1806 (24)	3425 (35)
ISCED levels 5 and 6; college or above	1411 (18)	1900 (19)
Body mass index (BMI)		
Mean (standard deviation)	28.8 (6.66)	26.7 (4.82)
Total range	10.6 to 82.7	15.1 to 77.8
Range covering 95% of the sample	19.4 to 44.9	19.4 to 37.6
Range covering 90% of the sample	20.3 to 41.0	20.2 to 35.3

TABLE B – The exact questions asked regarding cardiovascular outcome and risk factors for the American and European women.

	United States	Europe
Questions from	Health and Retirement Study (HRS)	Survey of Health, Ageing and Retirement in Europe (SHARE)
Heart disease	Has a doctor ever told you that you had a heart attack, coronary heart disease, angina, congestive heart failure, or other heart problems?	Has a doctor ever told you that you had a heart attack including myocardial infarction or coronary thrombosis or any other heart problem including congestive heart failure?
Stroke	Has a doctor ever told you that you had a stroke?	Has a doctor ever told you that you had a stroke or cerebral vascular disease?
High blood pressure	Has a doctor ever told you that you have high blood pressure or hypertension?	Has a doctor ever told you that you had high blood pressure or hypertension?
Smoking	Have you ever smoked cigarettes? Definition: By smoking we mean more than 100 cigarettes in respondents lifetime; do not include pipes or cigars.	Have you ever smoked cigarettes, cigars, cigarillos or a pipe daily for a period of at least one year?
Obesity (BMI≥30)	Based on BMI calculated from self-reported weight and height	Based on BMI calculated from self-reported weight and height
Weight	About how much do you weigh? In pounds	Approximately how much do you weigh? In kilos
Height	About how tall are you? In feet and inches	How tall are you? In centimeters

TEXT A – A more detailed description of sequence analysis

Of the 18,250 women in our sample, 15,542 women experienced distinct work-family life histories. This meant that 85% of the women in our sample had a work-family life history that was different from the work-family life histories of the other women in the sample. We wanted to cluster this diverse group of women into a few (work-family) typologies for analytical purposes. To do this, we used sequence analysis in which we identified work-family typologies based on the full set of work-family histories of the American and European women in our data.[A1–A3] Sequence analysis can account for both the timing of important events (in our case that would be, for example, marriage, childbirth, and having a new job) as well as the length of time spend in a given state following that important event (for example, being married, being a mother, and being employed). This gives sequence analysis an advantage over other methodologies that can account for only timing or duration, but not both.

The first step of the sequence analysis was to compute a measure of distance between any two of the women in our sample. This distance is defined in terms of 'costs' of transforming one woman's sequence to match it with the other woman's sequence. Costs are calculated on the basis of the number of edits (substitutions, insertions and deletions) that are necessary to transform one sequence into the other. The substitution costs of each possible transition were calculated based on the observed mean of that particular transition's probability in our sample.[A4] We have set indel (insertion and deletion) costs to 1, slightly more than half the highest substitution cost.[A5] We used the transformation with the minimum costs. More frequent transitions, for example transitions from being a nonworking married mother to being a working married mother, would have lower substitution costs than less frequent transitions, for example the transition from being a working married mother to being a nonworking single woman.

Then, hierarchical clustering was used to obtain distinct clusters of women where women within the same work-family typology were as homogenous as possible, while women categorized in different typologies were as different from each other as possible.[A6] To define the optimal number of typologies, we used different cluster cut-off criteria, including the Point Biserial Correlation and the Calinski-Harabasz index (Table C, available in the supplemental materials).[A7,A8] When considering the different criteria, both the five and six typology solution would have suited our data. When comparing these two solution to each other, we found that the five typologies solution provided us with more (sociologically) meaningful and argumentative typologies, while the six typologies solution yielded an additional typology that led to a more unclear and less argumentative pattern (Figure A, available in the supplemental materials). We therefore focused our main interpretation on the five typologies solution. This solution, in which all women were classified into one of the five work-family typologies, maximized the homogeneity of women within each typology, while also maximizing the heterogeneity of women of different typologies.

The sequence analysis was conducted using the TraMineR and Weighted Cluster packages in R version 3.2.1.[A6,A9]

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TABLE C – **Quality measures for number of clusters for women**

	Number of clusters			
Quality measures[C1]	5	6	7	8
Point Biserial Correlation (PBC)	0.58	0.57	0.58	0.59
Hubert's Gamma (HG)	0.76	0.78	0.80	0.81
Hubert's Somers D (HGSD)	0.76	0.78	0.80	0.81
Average Silhouette Width (ASW)	0.23	0.23	0.24	0.24
Average Silhouette Width (weighted) (ASWw)	0.23	0.23	0.24	0.24
Calinski-Harabasz index (CH)	2392.99	2073.01	1908.70	1717.57
Psuedo R2 (R2)	0.34	0.36	0.38	0.40
Calinksi-Harabasz index with squared distances (CHsq)	5326.45	4647.58	4437.57	4141.07
Pseudo R2 with squared distances (R2sq)	0.54	0.56	0.59	0.61
Hubert's C (HC)	0.14	0.13	0.12	0.11

Reference:

C1. Studer M. WeightedCluster library manual. A practical guide to creating typologies of trajectories in the social sciences with R. *LIVES Working Papers*, No. 24. 2013;24:1–32.

TEXT B – **A more detailed description of our counterfactual scenario analysis underlying the results in Table 2**

In the analysis presented in Table 2, we estimated the US probability of each cardiovascular risk factor or chronic disease (hereafter referred to as 'cardiovascular outcomes') under different counterfactual scenarios. We first combined estimates from the logistic models with the observed distribution of women over the work-family typologies in the US and Europe to calculate the observed probabilities of cardiovascular outcomes for US and European women. Using this data, we then estimated US counterfactual probabilities of cardiovascular outcomes under three different scenarios.

In the first scenario ("US counterfactual probabilities if European work-family typology distributions"), we estimated the US probability of each cardiovascular outcome under the counterfactual scenario that American women had been exposed to the same distribution of work-family typologies as European women. In the second scenario ("US counterfactual probabilities if European health risks associated with each work-family typology"), we estimated the US probability of each cardiovascular outcome under the counterfactual scenario that American women had been exposed to the same health risks associated with the work-family typologies as European women. In the third scenario ("US counterfactual probabilities if European work-family typology distributions and European health risks associated with each work-family typology"), we estimated the US probability of each cardiovascular outcome under the counterfactual scenario that American women had been exposed to the same distribution of work-family typologies as well as the same health risks associated with these typologies as European women.

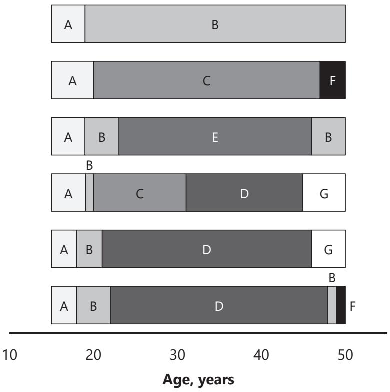
For each US counterfactual probability, we also calculated its difference with the observed US probability and the (observed) European probability to allow for a quick evaluation of changes in the US probabilities as well as changes in the US cardiovascular health disadvantage by the reader.

TABLE D – **Typology assignment by age and educational attainment, and percentage of women reporting cardiovascular diseases and risk factors in each work-family typology**

	Typology 1: Working single childless women	Typology 2: Nonworking married mothers	Typology 3: Working single mothers	Typology 4: Married mothers who returned to work after some nonemployment	Typology 5: Working, married mothers
United States					
Age, No. (%)					
50 to 54 years	135 (15)	143 (16)	131 (15)	286 (33)	177 (20)
55 to 59 years	176 (13)	233 (17)	192 (14)	430 (32)	305 (23)
60 to 64 years	109 (8)	256 (20)	129 (10)	452 (35)	362 (28)
65 to 69 years	117 (6)	524 (29)	166 (9)	586 (32)	421 (23)
70 to 72 years	44 (7)	203 (31)	48 (7)	213 (33)	147 (22)
Educational level[a], No. (%)					
ISCED levels 0 and 1	90 (6)	619 (39)	271 (17)	380 (24)	219 (14)
ISCED level 2	226 (8)	753 (26)	277 (10)	927 (32)	701 (24)
ISCED levels 3 and 4	193 (11)	342 (19)	209 (12)	600 (33)	462 (26)
ISCED levels 5 and 6	262 (19)	188 (13)	111 (8)	492 (35)	358 (25)
Reporting risk factors and chronic diseases, No. (%)					
Heart disease	80 (14)	251 (19)	145 (22)	318 (16)	237 (17)
Stroke	23 (4)	58 (4)	53 (8)	88 (4)	45 (3)
High blood pressure	263 (45)	774 (57)	376 (56)	1060 (54)	720 (51)
Smoking	292 (50)	643 (47)	406 (61)	1018 (52)	702 (50)
Obesity	215 (37)	539 (40)	285 (43)	679 (35)	503 (36)
Europe					
Age, No. (%)					
50 to 54 years	246 (12)	414 (21)	149 (7)	527 (26)	675 (34)
55 to 59 years	260 (10)	640 (26)	166 (7)	640 (26)	786 (32)
60 to 64 years	246 (11)	676 (30)	114 (5)	560 (25)	678 (30)
65 to 69 years	191 (10)	715 (37)	70 (4)	470 (24)	485 (25)
70 to 72 years	88 (11)	320 (42)	21 (3)	157 (20)	182 (24)
Educational level[a], No. (%)					
ISCED levels 0 and 1	231 (9)	1097 (44)	78 (3)	513 (21)	562 (23)
ISCED level 2	198 (10)	684 (35)	107 (6)	477 (25)	475 (24)
ISCED levels 3 and 4	384 (11)	783 (23)	203 (6)	936 (27)	1119 (33)
ISCED levels 5 and 6	274 (14)	217 (11)	147 (8)	506 (27)	756 (40)
Reporting risk factors and chronic diseases, No. (%)					
Heart disease	64 (6)	181 (7)	40 (8)	186 (8)	193 (7)
Stroke	15 (1)	47 (2)	8 (2)	56 (2)	53 (2)
High blood pressure	270 (26)	1011 (36)	150 (29)	755 (32)	937 (33)
Smoking	179 (45)	268 (29)	138 (60)	439 (44)	559 (39)
Obesity	175 (17)	649 (24)	110 (21)	510 (22)	572 (21)

Note. [a] ISCED levels 0 and 1: less than high school, ISCED level 2: high school or equivalent, ISCED levels 3 and 4: some college, ISCED levels 5 and 6: college or above

Typologies	All (n=18,250), No. (%)	US (n=7681), No. (%)	Europe (n=10,569), No. (%)
1. Working single childless women	1958 (11)	771 (10)	1187 (11)
2. Nonworking married mothers	5000 (27)	1903 (25)	3097 (29)
3. Working single mothers	1447 (8)	868 (11)	579 (5)
4. Married mothers who returned to work after some nonemployment	2549 (14)	1171 (15)	1378 (13)
5. Working married mothers	4826 (26)	1740 (23)	3086 (29)
6. New cluster	2470 (14)	1228 (16)	1242 (12)



[A] Nonworking, not married, with no child(ren)
[B] Working, not married, with no child(ren)
[C] Nonworking, married, with child(ren)
[D] Working, married, with child(ren)
[E] Working, not married, with child(ren)
[F] Nonworking, married, with no child(ren)
[G] Working, married, with no child(ren)

FIGURE A – The six typologies solution

Note. The five typology solution is presented in Figure 2 of the main text.

Discussion

Chapter 7

General discussion

This thesis presents a collection of studies focusing on the role of social inequality in explaining the US health disadvantage, addressing a critical question: To what extent is the worse health of Americans driven by their potentially larger health inequalities by education, employment status, marital status, and other work and family factors? The main findings of these studies are summarized and discussed in this final chapter. Part of the discussion includes methodological considerations as well as interpreting results in light of findings from previous research. Lastly, directions for future research as well as policy implications are outlined.

MAIN FINDINGS

First research question

What is the contribution of inequalities in health by educational level to differences in health and mortality between the United States and European countries?

Chapter 2 investigated to what extent larger educational inequalities in the United States compared to seven European countries (Belgium, Denmark, Finland, France, Norway, Sweden, and Switzerland) explained the higher mortality observed in the United States. Chapter 3 examined and compared changes in educational inequalities in mortality over time in the US and seven European countries or regions, namely Belgium, Denmark, Finland, Turin (Italy), Slovenia, Sweden, and Switzerland.

Educational inequalities in health may contribute to the explanation of the US health disadvantage in two distinct ways: via differences in the educational distribution or through differences in the effect of education on health. We found that the first does not play a role: actually, the educational distribution of the United States is more favorable than that in Europe (Chapters 2 and 3); i.e., the proportion of the American population with higher education is larger than the proportion in (most) Western European populations. Overall, all-cause mortality was higher in the United States than in many Western European countries, but we demonstrated in Chapter 2 that without this more favorable educational distribution US mortality would be even higher. Using the relative index of inequality, a measure of inequality that takes into account the educational distribution, we found that educational inequalities in mortality remained larger for American men and women than their European counterparts, despite their more favorable educational distribution (Chapter 3).

By contrast, we found that the second explanation does apply: educational inequalities in health were observed for men and women both in the United States and in Europe, but relative inequalities in mortality were larger in the United States than in the European countries examined. If American men and women would have experienced the same relative risk of mortality associated with lower levels of education as observed for Western European men and women, mortality for the total US population would be lower (Chapter 2). These relative inequalities increased between the 1990s and 2000s for both Americans and Europeans, but this increase was larger for Americans (Chapter 3).

In summary, the more favorable educational distribution observed for Americans when compared with that of their European counterparts means that differences in the distribution of education did not contribute to higher US mortality relative to European countries. By contrast, the higher mortality risk associated with lower education in the US than in Europe partly contributed to the larger overall mortality in the US than in the European countries we examined.

Second research question

What is the contribution of work and family factors to differences in health and mortality between the United States and European countries?

Chapter 4 examined whether explanations for relative educational inequalities in mortality differed between men and women, and whether work and family factors, separately, played a role in explaining these inequalities, alongside material and behavioral risk factors. Chapter 5 explicitly assessed the interaction between marital status and labor force participation on mortality in the US and six European countries or regions (Austria, England and Wales, Finland, Hungary, Norway, and the Basque country, Spain). Chapter 6 presented a study on the link between work-family life histories and cardiovascular diseases and risks later in life for American and European women.

Before examining whether work and family factors played a role in explaining the US health disadvantage, we assessed their relationship with health and mortality. Because this relationship is likely to be different for men and women, we explored patterns separately for men and women. In Chapter 4, we found that unemployment was associated with higher mortality (compared to employment) for men, but not for women, and a blue collar occupation of the breadwinner was associated with higher mortality (compared to the breadwinner's white collar occupation) for women, but not for men. These specific work factors, employment status for men and occupational class of the breadwinner for women, explained some of the within-country educational inequalities in mortality. We also found that while distributions of marital status, living arrangement status, and number of children were not very different for men and women, the mortality risks associated with being previously married or living alone were stronger for men than for women. Nevertheless, these family factors did not explain within-country educational inequalities in mortality for either men or women.

The next question addressed was whether work-family factors, in interaction, are associated with health outcomes. For this purpose, we used data from the United States and several European countries. Differences in the proportion of the combination of work and family factors could lead to health differences between countries, even if there are no differences in the associations of these combinations with health. Results suggest that differences in the distribution of work-family factors or in the association between work-family factors and health between the United States and Europe do not contribute to the US health disadvantage. In Chapter 5, we showed that the population distributions of marital status and labor force activity differed between American and European men and women respectively. Generally, the proportions of Europeans who were married or active in the labor market, viewed separately, were higher than those observed for Americans. As a result, when considering the joint distribution, American men and women were more likely to be both unmarried and inactive in the labor market (the 'less healthy' combination) and less likely to be both married and active in the labor market (the 'healthier' combination) when compared to their European counterparts. These differences in the distribution of work and marriage combinations partly contributed to the higher mortality in the US than Europe.

In Chapter 6, we used life histories to examine how differences in work-family typologies over the life course contributed to differences in cardiovascular diseases and related risk factors in later life between the US and European countries. We found similar distributions of work-family typologies between ages 16 and 50 years based on combinations of employment, marital status, and having children for older American and European women. There was one key exception: American women were more likely to have experienced a history of working lone motherhood earlier in life, an exposure that was strongly associated with increased risk of poor health in both Europe and the US. However, these differences were relatively small, so that if American women would have been exposed to the same distribution of work-family typologies as European women, their overall probabilities of cardiovascular diseases and risk factors would still be higher than those in European countries.

Second, different associations between work and family factors and health may also result in health differences between the United States and Europe; e.g., not being married or not being employed may be more detrimental for one's health in the United States than in Western Europe. However, the higher mortality risks associated with not being married (compared to being married) and being inactive in the labor market (compared to being active) were similar for Americans and Europeans (Chapter 5). Evidence of interactions between marriage and labor force activity on mortality were found for both men and women, but again results were similar for the United States and Europe. Chapter 6 showed that also the associations of the work-family typologies with cardiovascular health risks were similar for American and European women. For example, working lone motherhood was consistently associated with worse cardiovascular health outcomes, but there was no evidence that this specific association was stronger for American than for European women. If American women would have been exposed to all the same cardiovascular health risks associated with the work-family typologies as European women, their probabilities of stroke and high blood pressure would be lower, but their probabilities of heart disease, smoking, and obesity would be higher. Hence, this only explained a small fraction of the higher cardiovascular risk of American women.

In summary, differences in the distribution of and mortality risks associated with marital status and labor force activity between Americans and Europeans do not contribute to the US health disadvantage relative to Europeans. While there were some small differences in the distribution of and health risks associated with work-family typologies between the United States and Western Europe, these differences were too small to explain the worse health and higher mortality of Americans relative to Europeans.

METHODOLOGICAL CONSIDERATIONS

When interpreting the overall findings of the studies presented in this thesis, several methodological considerations should be kept in mind. Limitations specifically relevant for the separate studies included in this thesis have been discussed in the corresponding chapters. These limitations included cross-national differences in data designs, differences in the populations covered by the different data sources, differences in the education and work-family measures, and possible measurement error of (self-reported) data. Hence, this section focuses on overarching methodological considerations of the studies presented in this thesis.

Causality or selection

Inequalities in health and mortality by social factors such as education, employment, marital status, and other social factors have been widely documented in the literature. Educational inequalities in health have been reported for men and women at all ages in most, if not all, industrialized countries. Compared to individuals with higher education, lower educated individuals have higher mortality rates, (report) worse health and well-being, and are less likely to undertake healthy behaviors.[1–5] Unemployed individuals have worse health and higher mortality than their employed counterparts.[6–9] Compared to unmarried individuals, married individuals enjoy better physical and mental health, often engage in healthier behaviors, and have lower mortality rates.[10–14] Many studies have reflected on the associations between these factors and health. Yet, there is no consensus on whether these links are causal (i.e. whether the social factors affect health), due to selection (i.e. whether health affects the social factors), or due to confounding by third factors (i.e., whether both health and social factors are influenced by other determinants, such as personality characteristics or genetics).

Observing an association does not necessarily mean that the relationship is causal. It is often argued, although not fully agreed upon, that an experiment is the best approach to examine causal effects as it manipulates an exposure in an otherwise controlled environment.[15] In view of ethical and often also practical reasons, however, an experimental setting is not always appropriate or feasible. Quasi-experiments or natural experiments are therefore thought to be the best next approach as they seek to replicate an experimental setting using natural variation not manipulated by the investigator.[16] They allow researchers to evaluate the impact of an exposure that was influenced by changes in, for example, the economic environment or government policy, without it being correlated with the individual's personal characteristics or other factors that would affect the outcome of interest.[17]

Several studies have used quasi-experimental approaches to estimate the causal effect of education on health, using a variety of health outcomes ranging from mortality to biomarkers. Many of these studies examined the effect of (changes in) compulsory schooling laws,[18–27] either by using them as instruments in an instrumental variable (IV) approach or by using implementation dates as a cut-off within a regression discontinuity (RD) design. A common critique of the IV approach is that it may suffer from weak instruments; i.e., the exogenous shock (the compulsory schooling law) may only have a small effect on the average level of the exposure of interest in the population (education). Another critique is that it only estimates a local average treatment effect, as compulsory schooling laws only affect the educational choices of those who would not have gone to school beyond the required years, and the effect in this group may be different from the average causal effect of education on health in the population as a whole.[19] In the RD design, individuals before and after implementation are compared under the assumption that they only differ from each other with respect to their exposure to the schooling law (at least within a given geographical unit). Despite strong internal validity, the external validity of the results of an RD design is deemed questionable, as it only includes a very specific subgroup of the population.[28]

Another possible approach is that of a twin study design, i.e. linking within-twin differences in educational attainment to (possible) differences in health outcomes. By considering twins only, genetic and family characteristics are controlled for as these are shared between twins.[19] Common critiques of twin studies are power limitations (as the variation in education within twins is small), not controlling for in utero measures or health conditions since conception (as these may affect specific traits differently), their external validity (as compared to singleton birth, twins' experiences are unique), and the fact that different educational choices within twins, who share not only their genes but also their family background, may be due to factors that are correlated with later health, e.g., ability, parenting, or health problems earlier in life.[19]

Despite these limitations, it is important to consider what both quasi-experimental and twin studies tell us about the causal relationship between education and health. Overall, quasi-experimental studies generally suggest that there is a causal effect of education on mortality, but the magnitude and robustness of this relationship varies considerably by health outcome, country, and cohort.[19] Some of these differences in the effect of education have been linked to the different value of education by gender, as well as differences in labor market returns to education, the quality of education, and whether education affects the quality of individuals' peers.[19]

The aim of this thesis was to document and examine health differences by level of educational attainment in the United States and Europe. Observational epidemiological studies with more of an explorative or descriptive aim are sometimes viewed as inferior to those estimating causal effects, as "the determination that an association is causal can have profound public health consequences, signaling the need or at least the possibility to take an action to reduce exposure to a hazardous agent or to increase exposure to a beneficial one."[29(p62)] However, this belief does not acknowledge the value of other questions within public health that may also be relevant. Recently, it has been suggested that researchers should avoid any ambiguity regarding the research question, and thus be clear in whether the study aim is to estimate a causal effect or not.[30] In view of its descriptive aim, education was mainly used as a stratifying variable to capture health inequality within populations in this thesis. Chapters 2 and 3 specifically focused on differences in mortality by education, but we acknowledge that this relationship may emerge because less education caused worse health, because individuals with worse health were selected into having less education, because of confounding by other variables, or all of these. Chapter 4 is an exception, as here we assumed a causal effect of education on mortality, corresponding to the assumptions of a (traditional) mediation analysis. However, even in this chapter, our approach did not allow us to control for all possible selection of confounding factors between education, mediating factors, and mortality, limiting any causal claims that can be derived from the analysis. Our results should therefore be interpreted with caution as confounding is always a possibility, and hence we stated our results as associations.

Similar to the relationship between education and health, the relationship between work and/or family factors and health is also likely to be susceptible to both confounding and selection. According to the latter mechanism, healthier individuals are more likely to be employed, married, and to have children than their less healthy counterparts. For example, health problems may limit the type or amount of work an individual is able to perform,[31] or they may make individuals less attractive as a partner.[32] Furthermore, health problems may also complicate combining multiple roles – such as employment, marriage, and parenthood – for individuals, which may be largely due to selection. Associations reported in this thesis should therefore not be seen as causal estimates, but as an attempt to document and examine health differences by work and family factors for the United States and European countries.

An important question, when looking at the US health disadvantage, is whether selection into employment, marriage, and parenthood is similar for all countries or whether it differs across countries. It is within reason to think that this selection may depend on the economic and policy environment individuals live in. Notably, individuals may have to take up employment, even when suffering health problems, in an environment with less extensive unemployment or disability benefits such as the United States, than in countries with a more generous welfare state. By contrast, employment may thus be more of a choice rather than a necessity for individuals with health problems in countries with more extensive unemployment or disability benefits such as many European countries. If this were to be the case, and the pool of individuals in poor health who are employed would be larger in the US (because of their less generous social protection policies) than Europe, this would manifest in weaker health-related selection in the US than in European countries. This is because health would then more likely affect employment decisions in European countries than in the US, where many workers must work regardless of their health status. Overall, it is unclear to what extent these differences in the magnitude of selection between Europe and the United States may have contributed to our findings, but two considerations are worth mentioning. First, if health-related selection into employment, marriage, and parenthood were different between the US and Europe, we would generally have expected to observe different associations of these factors with health and mortality across the Atlantic. However, we found very little evidence that associations between these factors were stronger in the US than Europe. Second, part of the reason for this similarity in associations may stem from an actual stronger (causal) effect of these factors on health and mortality in the US than Europe (net of selection), which is compensated by a weaker selection effect in the former. If so, this may have resulted in an underestimation of the contribution of work and family factors to differences in health between the US and Europe. In other words, in a scenario in which selection into employment, marriage, and parenthood would be stronger in the US, and associations between these work-family factors and health and mortality are also stronger in the US than in Europe (net of selection), this would mean that the contribution of these risk factors would have been even larger than observed in our study. Overall, however, we have limited evidence so far that selection effects are stronger in one country than the other, and therefore these explanations remain speculative and require detailed panel data to disentangle selection from causation effects, an area worth of further study.

Measurement of social factors

When examining international differences in educational inequalities in mortality, it is important to acknowledge that differences in the measurement of educational attainment between populations may affect the overall results. In Chapters 2 and 3, we harmonized highest educational attainment in the United States and Europe by using corresponding levels of the International Standard Classification of Education (ISCED). For the European countries, these ISCED levels were already provided. For the United States, education in the US was measured as years of schooling. Even though the International Standard Classification of Education aims at harmonizing levels of educational attainment across different countries to allow for international comparisons, possible discrepancies may still exist. For example, we cannot completely rule out that (aspects of the) educational systems or practices and curricula differ between countries.[33] However, the observed differences between the United States and Europe seem too large to be only resulting from these unaccounted differences in international educational systems.

Besides how education is measured, the measurement of other social factors such as employment, labor force activity or marital status may also differ between countries and data sources. In Chapters 4 to 6, we used rather crude measures of labor force activity and employment. In Chapter 4, we included an individuals' own type of employment (employed, unemployed, retired, and not in the labor force) as well as the occupational class of the breadwinner (professional, white collar, blue collar, and not in the workforce) as possible mediators on the pathway between education and mortality. In Chapter 5, we combined employed and unemployed individuals into the category 'active in the labor force', and compared them to individuals out of the labor force. In Chapter 6, we distinguished women who have worked for pay during a year or not to represent their employment status. Cross-national differences in these measurements may have affected our results. For example, international differences in the proportion of the population being unemployed may have affected cross-national comparisons of labor force activity status. Whereas differences in the prevalence of certain types of employment, such as self-employment or part-time employment, may have also been of influence. Overall, these measures of labor force activity and employment are rather broad, and we may have missed more subtle inequalities consequently. For example, full-time employees might be better off in terms of their health than part-time employees, or individuals choosing to be homemakers might fare better in terms of their health than individuals out of the labor force due to disability. Including more specific measures of employment may thus help our understanding of what elements of employment may be associated with (educational) inequalities in mortality. As these factors may also vary between countries, they may inform us about the relationship between these factors and health, as well as their possible contribution to the US health disadvantage.

In these same chapters, more general measures were used to represent family life. In Chapters 5 and 6, an individual's marital status was either currently married or not currently married. However, as a result of data availability, we were able to add the category of previously married to Chapter 4, allowing for some nuance between never married individuals and those who were divorced or widowed. Nevertheless, also here we might have missed some more subtle inequalities. For example, individuals in a cohabiting relationship could not be distinguished from those living alone and never married (Chapters 5 and 6), despite the fact that previous research has shown that cohabiting individuals are better off in terms of their health than those not living with a partner.[34,35] In Chapter 4, we distinguished individuals with no, one, two, or three or more children living at home, whereas in Chapter 6 individuals were classified as parents when they had at least one child under the age of 18 years. Here, more subtle differences in health might have also gone undetected. For example, we could not distinguish younger children from older children in the family.

Use of different methodologies

In this thesis, several different methodologies have been applied to assess the relationship between education and health, and work and family factors and (educational inequalities in) health. The methodology applied in each chapter was determined by the specific research question and the available data, as some methodologies were specifically suitable for certain data structures.

In Chapters 2, 3, and 5, Poisson models were used to assess (differences in) educational inequalities in mortality in the United States and several European countries. We chose to use Poisson models, as these were particularly suitable for analyzing our European data; these data were available in an aggregated form, often for total populations, providing a count of deaths and number of person-years disaggregated by personal characteristics, e.g., sex, five-year age group, and educational level. For the United States, we used data from the National Health Interview Survey, either directly from its source (Chapter 2), or harmonized by IPUMS (Chapters 3 and 5).[36] Compared to the wide coverage of the European data, the US data provided us with a relatively small sample and thus increased uncertainty surrounding estimates. Nevertheless, our studies were among the first to examine inequalities in mortality by education, marital status, and labor force status, while directly comparing the United States with European countries, often using data covering total European populations.

In Chapter 4, Cox proportional hazard regression models were used to examine the contribution of material, employment-related, behavioral, and family-related factors to educational inequalities in all-cause and cause-specific mortality, and whether these differed for men and women. To do this, we followed the steps of a (traditional) mediation analysis.[37,38] Potential biases of this method are mediator-outcome confounding (when there is confounding affecting both the mediator and the outcome) and exposure-mediator interaction (when the direct effect of the exposure varies by levels of the mediator).[38] Mediator-outcome confounding can, in principal, be handled by the methodology, given that all potential confounders are measured.[38] If these remain unmeasured, the methodology will not provide unbiased results, however this is the case for any other method. In this chapter, data from the baseline measurement of the GLOBE study with almost 23 years of mortality follow-up were used. Using observational data to examine the contribution of factors to educational inequalities in mortality has some important limitations, including the cross-sectional nature of the exposures and the use of self-reported measures. But on the other hand, this dataset also had several advantages over other data sources, including the availability of an extensive set of measures of material, employment-related, behavioral, and family-related mediators, as well as the lengthy mortality follow-up provided through linkage with death records from Statistics Netherlands. Our study was the first to include family-related factors as possible mediators on the pathway between education and mortality, and it highlights the importance of a gender perspective in research on educational inequalities in mortality and the factors contributing to the explanation of these inequalities.

In Chapter 6, sequence analysis was used to assess the association of work-family typologies of American and European women with cardiovascular health outcomes. Data from the Health Survey and Retirement Study (HRS) were used for the United States, while data from the Survey of Health, Aging and Retirement in Europe (SHARE), were used for the 13 European countries. As SHARE was developed as a sister study to the HRS, their overall compatibility is good, although there were some differences in design, particularly regarding the retrospective data collection, as well as response rates. The extensive retrospective data that were available, allowed us to employ a rather novel methodology in public health research, namely sequence analysis. In contrast to the previously mentioned models, sequence analysis takes a holistic view of an individual's history rather than focusing on (one of) its dimensions. In Chapter 6, we examined how womens' work-family life histories from ages 16 to 50 years were associated with cardiovascular health and risk factors. Sequence analysis uses the timing, order, and duration of each possible work-family combination over the life history to derive distinct clusters of women with similar work-family trajectories. An advantage is thus that it focuses on the overall similarities and differences of the complete trajectory, rather than similarities or differences at specific ages. However, by taking this holistic view, it remains difficult to exactly pinpoint what aspect of the trajectory is beneficial or detrimental for an individual's health when the trajectory is considered altogether. Nevertheless, our study is one of the few using sequence analysis on work-family life history data for both American and European women and examining overall life trajectories and their link to cardiovascular health and risk factors in mid-life.

These different methodologies show the diversity of approaches used in this thesis to assess the relationship between social factors and (educational inequalities in) health. With regards to education and health, the structure of the data and the analytic models used in Chapters 2 and 3 were similar. Their results are also very much in line with each other; absolute and relative inequalities in all-cause mortality were generally larger in the US than in the European countries, for both men and women, and both in the 1990s and 2000s. With regards to work-family factors and health, in Chapters 4 to 6 several different types of data and estimation techniques were used. Nevertheless, the conclusions of these chapters are in agreement with each other in general, namely that work-family factors do not contribute to cross-national differences in health, or to differences between countries in educational inequalities in mortality.

INTERPRETATION OF THE FINDINGS

A disadvantage of Americans in terms of health and mortality, as compared with Europeans, has been reported by many studies.[39–45] The National Research Council and the Institute of Medicine devoted multiple reports to international comparisons between the United States and other high-income countries to study the US disadvantage in life expectancy and mortality.[46–48] These reports showed that the US health disadvantage affects Americans of all ages, is more pronounced among women than among men, is observed for multiple health outcomes, and increased over the past three decades. The studies in this thesis support these previous findings of a US health disadvantage for mortality, but also other health outcomes such as cardiovascular diseases outcomes. Our findings are also in line with other studies that have found a US health disadvantage in terms of self-reported health, behavioral risk factors,[41] self-reported illnesses and biomarkers,[41,42] chronic diseases,[44,49] disability,[44] amenable mortality,[39] all-cause mortality,[40] and life expectancy.[43]

Educational distributions and mortality

Contrary to recent findings for the US, Mackenbach and colleagues[50,51] found that there are no indications of an unfavorable mortality trend among low educated Europeans. They reported that mortality rates improved for low educated adults in most European countries in recent years, and did not deteriorate as observed for low educated Americans.[50] There are some indications that overall declining or stagnating life expectancy is not necessarily unique to the US, and for example also observed in the United Kingdom in recent years (2014–2016).[52] However, these were not examined by educational attainment. Nevertheless, this finding may be a sign of future fluctuations in life expectancy in more countries, and thus will remain an area worth researching in the future, especially an examination of these trends by education.

A large contributor of changing educational distributions within populations over time is the educational expansion observed in the last several decades; average educational levels increased in all (developed) countries. For example, the share of the American population aged 25 years and older that had lower secondary education or less (ISCED levels 0 to 2) decreased from 34.3% in 1970 to 10.9% in 2016, whereas the share with tertiary education or more increased from 21.3% to 43.5% for the same period.[53] This educational expansion had a vigorous impact on the educational composition of populations, and it is questionable whether being low (or high) educated has the same implications for an individual's life now, for example in terms of their health or labor market chances, as it did in the past. For example, if an American had less than upper secondary education in 1970, he/she was 1 out of 3, whereas if an American has less than upper secondary education nowadays, he/she is only 1 out of 10. As 9 others did complete at least upper secondary education, this one individual who did not may be disadvantaged in more ways. Therefore, it is perhaps not surprising that lower educated Americans today look worse off in terms of health and mortality than those with lower education several decades before. These compositional changes to the educational distribution, resulting in a smaller and growingly selective group of lower educated which may also be more homogenously unhealthy, have received much attention over the last decade as a potential explanation of changing disparities in mortality by education.[54–59]

Several approaches have been applied to examine to what extent these changes over time in the composition of educational groups in the US may have influenced overall mortality estimates. For example, Meara and colleagues[56] reassigned some individuals with low education to the high educated group in one time period to equalize educational shares between two time periods. Despite this adjustment, they still found increased educational gaps in life expectancy due to gains in life expectancy mainly happening among the higher educated. Hendi[58] used an approach broadly similar to that of Meara and colleagues,[56] as he reassigned individuals to adjacent educational categories to ensure that all periods had a similar educational distribution. His findings suggest that compositional changes over time played a central role in explaining changing educational gradients in US life expectancy, but they do not fully account for the decreasing life expectancy among low educated American white women. Both Meara and colleagues[56] and Hendi[58] estimated life expectancy at age 25, but differences in their measures of education, the included age groups, and the time period studied may explain the difference in their results. Taking a different approach, Bound and colleagues[57] used an individuals' educational relative rank within their birth cohort to categorize their educational attainment. When accounting for relative ranks, they still found that the survival probabilities of low educated Americans, women particularly, did not change between 1990 and 2010, but that the survival probabilities for those with higher levels of education improved. Generally, these findings suggest that some of the increasing disadvantage of low educated Americans may be explained by compositional changes to the low educated group within the United States, but that they do not explain all of the disadvantage.

Overall, the US educational system has been more successful in giving many individuals a higher level of education than the European educational systems in the second half of last century. This led to overall higher educational attainment levels for the US, but educational attainment levels have been increasing at a faster rate in other countries.[60] In 2017, the proportion of the population aged 25 to 34 years that attained tertiary education in the US was similar to those observed in, e.g., Sweden, the Netherlands, and Norway.[61] Even though tertiary educational attainment is more similar across countries nowadays, the proportion of Europeans with low education in the countries examined is still about twice as large as the proportion of Americans with low education.[61] Therefore, selection might at least be part of the explanation for trends in mortality in the lower educated groups, even if it may not offer a full explanation.

Larger educational inequalities in mortality in the US than in Europe

Educational inequalities in mortality were larger in the United States than in the European countries, which may (partly) explain the US mortality disadvantage. Possible explanations for these larger educational inequalities in mortality in the United States include differences in health care systems, differences in the availability of dangerous prescription drugs and other factors associated with 'deaths of despair', but also rural-urban differences and larger inequalities in material circumstances and unhealthy behaviors. A recent study by Mackenbach and colleagues[50] suggested that European health care systems may indeed have played a role in constraining inequalities in mortality in Europe.

We found that mortality increases from causes other than cancer or cardiovascular disease primarily drove the US mortality increase (Chapter 3). International differences in health care systems may possibly explain this finding. With regards to care related to cancer, the US seemed to do generally better than Europe. For example, compared to European countries, cancer screening in the US is more extensive and 5-year survival rates from all major cancers were more favorable in the US than in Europe.[46] Additionally, the United States is also doing well in terms of health care related to cardiovascular diseases; the proportion of Americans with elevated blood pressure or cholesterol levels who receive medication is higher than that of Europeans, and the survival rates following a heart attack or stroke are generally also favorable in the US compared to other countries.[46] Therefore, it cannot be concluded that a poor performance of the US health care system accounts for the US health disadvantage. However, inequalities in access to care are generally larger in the US than in Europe, which may result in not all socioeconomic groups being able to benefit similarly from these medical advances. Whereas coverage is still mainly provided through private health insurance in the United States, in other OECD countries it is mainly provided through government schemes and compulsory health insurances.[62] Although there are several government insurance programs in place in the US, including Medicare (covering individuals aged 65 years and older, certain younger individuals with disabilities, and people with specific medical conditions such as end-stage renal disease) and Medicaid (a programme intended for those with limited resources), the proportion of the US population that remains uninsured against health care costs remains to be larger than that of other high-income countries.[63] In the US, a large educational gradient in health insurance coverage exists; for example, the proportion of the US population aged 26 to 64 years that was uninsured was 27.3% for individuals with less than a high school diploma, 15.2% for individuals with a high school diploma, and 11.6% for individuals with some college but no diploma in 2016.[64] A gradient like this is less likely to be present in European countries that have a universal health insurance system in place. Partly due to the extent of health insurance coverage in a country, but also because of other reasons (such as the amount of out-of-pocket payments), the unmet needs of individuals due to costs is an important concern, especially among individuals with a low income.[62] Overall, the absence of a universal health insurance system in the US may have contributed to some of the larger educational inequalities in mortality in the US than those observed for Western European countries.

Important to note is that in 2014 the United States introduced the Patient Protection and Affordable Care Act, which was designed to expand insurance coverage. As a result, the share of the US population aged 18 to 64 years that was uninsured decreased substantially; for example it decreased from 22.3% in 2010 to 12.8% in 2015. However, the Affordable Care Act was only introduced after the study periods of the studies included in this thesis.

Health behaviors vary across educational groups,[46,65,66] and these variations may be larger in the United States than in Western Europe. A substantial proportion of educational inequalities in male mortality has been attributed to smoking.[67] However, another study suggests that smoking made an important contribution to explaining educational inequalities in longevity for white women, but not for men, in the US around 2000.[68] The relationship between education and smoking differs substantially between cohorts, gender, and countries.[69] Additionally, it also varies depending upon the stage of the smoking epidemic, implying that "the historical circumstances of countries that determine the start and peak of the epidemic shape disparities in both tobacco use and health overall."[69(p48)] Especially among women, the smoking epidemic started earlier and reached a higher peak in the United States, therefore larger inequalities in smoking in the US offer a potential explanation for larger educational disparities in mortality in the US.[46,70,71]

Furthermore, the prevalence of obesity and overweight is higher in the United States than in Western Europe.[72,73] Educational disparities in obesity exist in most, if not all, OECD countries;[73] lower educated individuals are more likely to be obese than their higher educated counterparts. Overall, obesity rates have increased more among the lower educated men and mid educated women in most OECD countries. However, in the United States, obesity rates increased most among high educated individuals.[73] If these trends continue, educational inequalities in obesity in the US are likely to be smaller than in other OECD countries as the prevalence of obesity will be higher for all educational groups in the US. It will therefore be less probable that these educational inequalities influence educational inequalities in general health in the US.

Mixed results have been found regarding educational inequalities in alcohol use, as higher educated women generally were more likely to be hazardous drinkers than their lower educated peers, whereas the opposite was true for men.[74] However, this pattern does not hold for all countries; for example, in the United States, hazardously drinking was also negatively associated with higher education for men.[74] Overall, no clear differences between the United States and Western Europe were observed, and therefore it is unlikely that this will explain the larger educational inequalities in mortality for Americans than Europeans.

The United States is characterized by relatively higher levels of income inequalities[75] and residential and racial segregation[76–78] than any Western European country. For example, the Gini coefficient, a common measure of income inequality, is higher for the United States than many Western European countries.[79] Larger income inequality, as well as residential segregation, expose those in the lower socioeconomic groups to worse material living circumstances. Ample evidence shows how this may affect health. For example, access to healthy food environments may be worse for Americans than Europeans, especially in the lowest socioeconomic groups, resulting in a larger disadvantaged position of Americans than Europeans in terms of healthy dietary intake and obesity.[80] Also, income-related inequalities in health insurance coverage, access to health care,[81] and ultimately health care utilization[82] were larger in the United States than in other high-income countries. The worse material circumstances in which the low educated live as compared to their higher educated peers, such as a higher risk of economic deprivation, less resources to adopt a healthy lifestyle, and unhealthier work and home environments, may allow for some of the educational differences in health within a country. As these differences in material circumstances may be larger in some countries than others, it is not unreasonable to think that income inequality and other material inequalities may thus possibly add to the explanation of the larger educational inequalities in mortality in the US than in Europe. However, evidence that the relationship between income inequality and health outcomes is causal is not convincing enough (yet) to make a strong statement about the role of this specific factor,[83] and research comparing the effect of material living circumstances om mortality between the US and European countries is mainly absent.

Different trends in mortality by education in the US than in Europe

Absolute and relative educational inequalities in mortality increased more in the United States than in Europe due to increasing mortality among lower educated women (Chapter 3). In the European countries, mortality declines were shared (more) equally by educational groups. In their first study, Case and Deaton[84] found a marked deterioration in the mortality of middle-aged white non-Hispanics in the United States between 1999 and 2013, which was strongest for individuals with less education, and was largely accounted for by increasing death rates from drug and alcohol poisonings, suicide, and chronic liver diseases and cirrhosis. Deaths from these causes have been labelled 'deaths of despair', because these mortality increases were concentrated among the lowly educated who in the United States have experienced increasing economic and social disadvantage.[84] Although many other scholars have commented on Case and Deaton's study and their findings, including possible urban-rural differences in these mortality trends that were unaccounted for,[85] a possible aggregation bias due to the relatively broad age category and overlooked gender differences,[86] and the deaths of despair not explaining all of the change in mortality,[87] Case and Deaton's finding of worse health among non-Hispanic white Americans compared to their peers from other countries persisted.

Recent research showed that the unfavorable trend of increasing mortality mainly occurred among white non-Hispanic Americans living in either suburban or rural areas.[88] Most of these mortality increases were found for suicide, accidental poisoning, and liver diseases, all included among the 'deaths of despair'.[84] These findings suggest that this effect is mainly concentrated among low educated White Americans living in rural areas, and are largely the result of economic, behavioral, and social factors.[88] Compared to (large) urban areas, poverty in suburban areas increased, and rural areas experienced more economic burden, a disadvantage in terms of access to quality health care, but also unhealthier behaviors such as more smoking,[89] less physical activity,[90] worse diets (e.g., higher fat consumption),[91] and higher likelihood of being obese (mainly among younger adults aged 20 to 39 years).[91,92] These may be related to the "underlying social and economic factors in these communities,"[88(p1541)] although evidence of a causal link of the 'deaths of despair' with these economic and social factors remains to be explicitly examined.

Work and family factors do not help in explaining the US health disadvantage

Although the studies in this thesis should be seen as exploratory, our findings generally suggest that work and family factors are unlikely to be a main explanation of the US health disadvantage. We found that family factors did not explain within-country educational inequalities in mortality for either men or women. Additionally, the similarity of the distribution of and mortality risks associated with marital status and labor force activity for Americans and Europeans does not contribute to the explanation of the US health disadvantage. In a similar way, the small differences in the distribution of and risks associated with work-family typologies between the United States and Western Europe also do not allow for an explanation of the worse health observed among Americans.

We hypothesized that more American women would face the prospect of combining work and family roles, due to relatively high fertility rates and larger increases in labor force participation among American women. However, we did not necessarily find this. Previous studies have shown that employment of US mothers is dependent upon their marital status. For example, mid or high educated married US mothers were less likely to be employed than their Finnish counterparts, whereas the likelihood of employment was similar for unmarried mothers in both the US and Finland.[93] This is in line with a study reporting that marriage was negatively associated with employment in the United States, but positively associated in Finland.[94] However, relative mortality risks were similar for women combining employment and childrearing in the US and Finland.[93]

We also hypothesized that as a result of different work-family policy environments in the US and Western Europe, work-family trajectories could be related differentially to cardiovascular health in the US than in Europe. In general, our findings did not support this hypothesis as we only found small differences in the composition of and cardiovascular risks associated with work-family typologies over the life course of American and European women. This raises the question of whether other factors might be more important in explaining the worse cardiovascular health of US women. Here, smoking, obesity, and other unhealthy behaviors may come in and fulfil an important role as the literature suggests that these factors are partial explanations for the overall US female health disadvantage.[46–48,95,96]

However, we did find that combining work and parenthood while having little (spousal) support, often represented by (working) lone motherhood, may be detrimental for a woman's cardiovascular health in later life, and this association may be stronger for American women than European women. Although these differences did not explain much of the US health disadvantage, it is important to consider the potential explanations for this finding. In most high-income countries, lone motherhood has been associated with a higher likelihood of poverty.[97] Previous studies found that this association was stronger in the US than in Europe,[98,99] although others found similar associations for the United States and Scandinavia.[100] The more generous family policies in Europe such as those providing paid maternity leave, better child care and support, and the possibility to work part-time, may partly counteract the negative effect of poverty and related stress.[101] As a result, American (working) lone mothers may have had more difficulties making ends meet than their European counterparts, and as a result they may thus have experienced a more stressful life due to less supportive policy regimes. The lack of support policies for (young) mothers and families in the US,[99] notably maternity leave, might have facilitated a more stressful life. Also important is the structure of the health insurance systems in different countries, as the US system relies heavily on employer-based health insurance compared to more universal health insurance coverage in most Western European countries. Therefore, compared to Western European lone mothers, US lone mothers may have required a stronger attachment to the labor force in order to have health insurance for themselves and their children.[102] As a result, American lone mothers who were not employed, and thus lacked (employment-related) health insurance, may have experienced reduced health care access relative to similar European mothers whose access to health care was not dependent on employment and guaranteed by government law.[103]

Similar to education, specific work or family factors may mean different things for individuals exposed to different contexts. One way the contexts may differ could be differences in culture and government policy, both of which lead to cross-country differences in employment and family formation decisions. For example, the general acceptance of non-marital cohabitation, with regards to legal marital status, differs strongly between countries. For that reason, cohabitation may be chosen for different reasons by individuals from different countries. For example, individuals may choose cohabitation as an alternative living arrangement to marriage.[104] This may occur more often when they live in a country where cohabitation is culturally approved and there is better institutional support for children raised out of wedlock.[104] Results from a study by Heuveline and Timberlake[104] showed that in the United States cohabitation is often chosen as an alternative to singlehood, whereas in Finland it is more often chosen as a stage in the marriage process, and in France as an alternative to marriage. Another example is the prevalence of part-time employment among women. If part-time employment is not encouraged either by society or (governmental) policies, women who take up part-time employment in these environments may be different (either in characteristics or in outcomes) from part-time employed women living in societies where it is common or incentivized by government policy.[105] If work or family factors thus could mean different things for individuals from different countries, then we may have measured different things, even though we used a similar indicator for the different countries.

RESEARCH AND POLICY IMPLICATIONS AND RECOMMENDATIONS

Implications and recommendations for future research

Current evidence for explaining the US health disadvantage when compared to European adults, is scarce. This thesis aimed at explaining the US health disadvantage by examining the contribution of education, and work and family factors. Many studies, including ours, look into possible explanations for the US health disadvantage. Possible explanations that have been previously studied include differences in the public health and medical care system, individual health related behaviors, factors related to the physical and social environment, and social factors.[46–48,106] For example, environmental factors related to the built and social environment, such as the high reliance on automobile transportation in the US or the wide availability of unhealthy foods, may play an important role in explaining the US health disadvantage.[48] We found that educational inequalities explain part of the US health disadvantage, whereas family factors did not. However, the US health disadvantage remains largely unexplained. As examining other factors was beyond the scope of this thesis, we acknowledge their potential contribution to the US health disadvantage. We recommend that future research focuses on the role of the public health and medical care system, particularly when trying to understand differences in specific non-communicable diseases such as cardiovascular disease and cancer. Additionally, as many factors related to the physical and social environment could be directly influenced by policy,[48] we would recommend future research to also consider these factors in more detail as they may guide us to possible policy interventions that eventually could reduce the US health disadvantage.

Recent trends in increasing mortality from deaths of despair, and particularly from opioid use, mainly among middle-aged men and women in the United States, warrant more research into how this may influence international differences in mortality at young and middle ages. Although at the moment the discussion of the opioid crisis has mainly focused on the American situation, increasing opioid (ab)use is also reported in European countries. For example, strong opioid prescriptions increased significantly for Norwegian adults between 2005 and 2010,[107] more than doubled in Scotland between 2003 and 2012,[108] and increased almost four-fold in Australia between 1990 and 2014.[109] Therefore, we recommend future research, especially studies focusing on more recent data, to examine how these developments may affect the US health disadvantage. Important here is that these studies would need comparable data for multiple countries with information on educational level, (cause-specific) mortality and ideally other health outcomes that may be more related to the opioid crisis, covering multiple years to study possibly changing contributions over time.

This thesis primarily used cause-specific and all-cause mortality to examine the US health disadvantage when compared to Western Europe. Advantages of using mortality as a health outcome is that it is a clearly defined measure, it is defined in a similar way across countries, and it is fairly easy to obtain from administrative data. All these advantages made it a very useful measure for our cross-national comparisons. However, on the other hand, mortality is a fairly crude and extreme measure of (bad) health. Leading risk factors for mortality (e.g., blood pressure) might be different from leading risk factors for disability (e.g., back pain). Therefore, the explanation of the US mortality and morbidity disadvantage might be fundamentally different too. Although we used cardiovascular health and risk factors as outcomes in Chapter 6, we recommend future studies to study (other) non-fatal outcomes. These measures are ideally not self-reported, and the data may come from cancer registries, hospital or medication records, and disease surveillance systems.

We used education as a measure of an individual's socioeconomic position. As there are also other measures that could have been used to represent socioeconomic position, such as occupation or income (which cannot be used interchangeably), we cannot be certain that the results in this thesis would also hold for these other measures. Therefore, we recommend future studies to examine multiple measurements of socioeconomic inequalities in mortality in the US and Western Europe to examine whether these play a similar role in the explanation of the US health disadvantage. Additionally, the international comparability of the measure of education and educational inequalities in general remains debatable. Future research should focus on comparing the US and Western Europe beyond educational level and possibly focus on differences in the educational systems between the two regions, or differences in the quality of education. A more detailed comparison of educational systems and the quality of education could inform research greatly by trying to disentangle what aspect of education may result in the observed cross-national differences.

This thesis concentrated on the contribution of family factors to within-country educational inequalities in mortality, and cross-country differences in mortality and cardiovascular health. However, we found no strong evidence of a contribution of family factors to either the explanation of educational inequalities in mortality, or the explanation of the US health disadvantage. In recent times, work and family life keeps changing; e.g., over time, marriage rates generally decreased,[110,111] divorce and non-marital cohabitation rates increased,[111] as well as increases in part-time and temporary employment.[112] These developments vary across countries, and these differences may contribute to variations in health trends and health inequalities. Although this thesis did not find strong evidence of work-family factors influencing educational inequalities in mortality or the US health disadvantage, these recent changes allow for a possible interesting line of future research. For example, the contribution of cohabitation or type of partnership (rather than married versus non-married), or the number of working hours (rather than having employment or not) may provide more insights in the possible pathways of work and family factors to health than the broad factors we have used in this thesis. However, this would require this data to be available, where at the moment this is not commonly available in (survey) data.

We studied marriage, work or other family factors as exposures, but we recommend to also focus on a better understanding of the impact of policies that affect the dynamics of work-family life. By understanding these policy impacts we may be able to say something more concrete about how government policy or the welfare state might impact health inequalities and health, and how these may differ between the US and Europe.

Many studies have reflected on the associations between the social factors studied in this thesis and health, yet there is no consensus on whether these links are causal, due to selection, or due to confounding by third factors. Even though the aim of this thesis was to document and examine health differences by level of educational attainment in the United States and Europe and not to estimate the causal effect of education on health, we strongly recommend future research to move towards more robust causal identification strategies. Research addressing selection into educational attainment, employment, labor force participation, marriage, and parenthood is strongly encouraged as these presumably play a large role, but they remain largely unmeasured. For example, the causal mechanisms behind the associations we observed are also likely to be more complex than we could explore with the data we had; for example, work and family factors could affect health directly, but also indirectly, e.g., by improving an individual's economic situation through employment or marriage, which is linked to better health. We therefore believe that our research field would greatly benefit from knowledge on these selection mechanisms and the causal effect of the social factors on health. This would require the use of more advanced causal identification strategies, such as causal mediation analysis and quasi-experimental approaches focusing on relevant policies. Additionally, suitable data, here longitudinal data covering a large proportion of an individual's life course as well as more specific measures of each social factor, would be needed.

Policy implications and recommendations

Educational inequalities in mortality were larger in the United States than in the European countries examined. Among Americans, and particularly among lower educated white Americans, mortality recently increased, while in Western European countries, mortality improvements were shared across all educational groups. The European health care systems have been credited with some role in constraining inequalities in mortality in Europe, as absolute mortality inequalities in Europe narrowed, and it has been speculated that this is due to equal relative effects of increasing health care expenditure for both low and high educated Europeans.[50] By contrast, the United States does not have a uniform health care system and far from a universal health insurance coverage. Partly as a result, individuals with a low socioeconomic position might not benefit as much from advances in health care as their higher socioeconomic status counterparts. Although inequalities in doctor visits exist between low and high educated individuals in most OECD countries, this inequity is generally larger in the United States than in European countries, particularly for specialist services.[113] Given the same need, high-income individuals were generally more likely to see a doctor than those with less income.[81,82] This inequality was also larger in the US compared to the other developed countries.[81,82] Overall, the increasing mortality among low educated Americans, which is not observed among low educated Europeans, suggest that there may be substantial health gains by improving access to quality health care for low educated individuals in the US. This may in turn also result in decreases in the US health disadvantage.

Additionally, compared to the United States, other high-income countries tend to invest more in social policies that may promote health. These more generous social protection policies (such as those observed in Europe) may have a positive influence on health. Several studies have examined the link between social policy expenditures and health in developed countries, although creating perfect comparability has proven difficult in view of practical and ethical reasons.[114,115] Even though the US spends a larger portion of their gross domestic product on health services than any other OECD country, their spending on social services is lagging behind that of other OECD countries. But this spending on social services appears to be beneficial for health; research indicates that the ratio of spending on social services to spending on health services may influence life expectancy beyond the influence of spending on only health services.[114] In line with these findings, if spending on education and incapacity programs in the US would be comparable to those of other OECD countries, life expectancy in the US could increase and consequently the US disadvantage (in terms of life expectancy) could decrease.[115] These investments have been linked to better population health, and could also decrease the health gap between the United States and Europe. Of all individuals, low educated individuals were most disadvantaged in terms of their health. Therefore, social policies specifically targeted at low educated individuals to improve their health would increase overall population health. Besides low educated individuals, other subgroups of the population were also at a disadvantage, e.g., lone mothers.[97] Therefore, work and family support policies specifically aimed at these subgroups should be studied more carefully to better understand how they may contribute to the worse health outcomes observed for these disadvantaged individuals. Social protection policies aimed at improving the health of the disadvantaged may include policies to reduce unfavorable work and/or family situations such as minimum wage policies, unemployment insurance policies, and childcare policies.

Besides a sole focus on low educated individuals, we suggest that policies should have a broader reach and also aim to improve the health and lives of individuals with 'mid' levels of education, who are also disadvantaged in terms of their health when compared to those with high education. However, this disadvantage is usually smaller than that observed among low educated individuals. If one would only focus on the disadvantage of the low educated and not include the mid educated, a substantial burden of health disadvantage may be overlooked. Improving the health and lives of individuals in this specific category, or by using interventions that span the entire socio-ecological spectrum, may prevent missing disadvantaged groups and lead to improvement of the health of the whole population.[116]

Nevertheless, the question remains whether the policy suggestions listed above will result in the desired health gains by focusing on specific dimensions, as opposed to an approach that focuses on distal, macro-level policies that shape multiple individual factors that were listed. Health determinants are "highly linked, complex, and operate at several levels of the social-ecological framework."[116(p66),117] It is therefore much more likely that they are interdependent, and that a poor health outcome or, more generally health inequalities, are the result of an interplay between all of these factors rather than the result of only one of these. Here, for example, low education, unhealthy behaviors, unfavorable economic, and family situations may all be interlocked in influencing an individuals' health. Many determinants of health and health inequalities may have origins that are beyond the direct effect of the health sector and health policies, but are rooted in the social, environmental, and/or economic environment.[118] Here, 'Health in All Policies' have come into play, described by the World Health Organization as "an approach to public policies across sectors that systematically takes into account the health implications of decision, seeks synergies, and avoids harmful health impacts in order to improve population health and health equity."[118(p2)]. Addressing determinants of health and health inequalities might thus be more complex than initially anticipated. Taking efforts to reduce obesity as an example, only improving physical access to healthier food in the supermarket may in itself not substantially reduce obesity, as also changes in agricultural policies, (additional) taxation on unhealthy foods, and improved financial access to healthier food may be needed.[116] Therefore, only addressing one of these factors, or only one dimension of a health determinant, may lead to a minimal impact, and policy should aim to influence the whole system to achieve improved population health and wellbeing.[119]

An example of a more inclusive policy approach to reducing socioeconomic inequalities in health was introduced in England in 1997, and continued until 2010. This has been referred to as 'the English strategy', which overall aimed at reducing the gap in life expectancy and the gap in infant mortality by 10%. It focused on 12 different indicators to reach these targets, including access to primary care, child poverty, housing, homelessness, but also diet and smoking.[120] Several studies have evaluated whether the English strategy has worked,[120–123] and the overall conclusion is that although it had some partial successes, it did not meet its own targets; i.e. it did not reduce the inequalities in life expectancy or infant mortality.[120] Suggested reasons for the less successful results of the English strategy are that it did not address the right entry-points and thus invested in entry-points that were irrelevant for the overall goal, it relied on policies that turned out to being ineffective in reducing health inequalities, and it was not implemented on a large enough scale to impact inequalities in health on a population level.[120] Even though the results of the English strategy were not as successful as hoped for, some valuable lessons can be learned from its implementation and evaluation. Substantial reductions in inequalities in health are possible, but only when governments are in a position in which they can make the necessary changes to policy, when the focus is on actual drivers of health inequalities within a population, when the effectiveness of policy is well-researched and proven before implementation, and when the implementation is carefully done and in line with attainable targets.[120] This type of strategy may therefore still remain to be of interest, and could have the potential to reduce inequalities in health within a population, such as the United States. As no single factor has been found to be responsible for the US health disadvantage, and multiple factors were found to be at least partially contributing to the US health disadvantage, a strategy combining different policy fields to address health and health inequalities should not be overlooked and may possibly contribute to a reduction of the US health disadvantage. However, the requirements needed for this type of strategy to be successful may be beyond our means at the moment.[120]

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Summary
Samenvatting

SUMMARY

Americans are worse off in terms of their life expectancy, many specific causes of death, and self-reported health measures when compared to individuals from other industrialized countries. This is often referred to as 'the US health disadvantage'. It is found to be larger for women than for men, and present across the entire life course. Several possible explanations previously discussed are the public health and medical care systems, health-related behaviors, the physical and social environment, and social factors. Even though this US health disadvantage has been studied extensively, researchers have not been able to fully identify the causes.

The aim of this thesis was to gain insight into the role of social inequalities, with a focus on education, work and family factors, in explaining the differences in health between the United States (US) and Western European nations. In the first part of this thesis, comprising of Chapters 2 and 3, we assessed the contribution of educational inequalities in health to the explanation of the US health disadvantage. Chapter 2 investigated to what extent larger educational inequalities in the US than in 7 European countries – Belgium, Denmark, Finland, France, Norway, Sweden, and Switzerland – explained the higher mortality observed in the US. European data came from censuses linked to national mortality registries, whereas the US data came from the National Health Interview Survey linked to the National Death Index. We included men and women aged 30 to 74 years for the period 1989 to 2003. Educational inequalities in health may contribute to differences in health between the US and Europe in two different ways; either via differences in the educational distribution or through differences in the effect of education on health. Results suggest that Americans had higher levels of educational attainment than Europeans. Therefore, the US mortality disadvantage would be larger if the US population had the same distribution of education as their European counterparts. By contrast, mortality differences between the US and Europe would be reduced by 20% to 100% if educational disparities in mortality within the US equaled those within Europe. Hence, larger educational disparities in mortality in the US than in Europe partly explain why US adults had higher mortality than their European counterparts. Policies to reduce mortality among the lower educated will be necessary to bridge the mortality gap between the US and European countries.

In Chapter 3, we examined changes in educational inequalities in mortality over time in the US and 7 European countries – Belgium, Denmark, Finland, Italy, Slovenia, Sweden, and Switzerland. All-cause and cause-specific mortality rates by educational level for the early 1990s and early 2000s were estimated and then compared between the US and the European countries. Data from mortality registries were used for the European countries and data from the National Health Interview Survey linked to the National Death Index for the US. We included men and women aged 35 to 74 years for the period 1989 to 2006.

Absolute inequalities in mortality increased significantly more in the US than in Europe due to increasing mortality among the lower educated, in particular for women. In the European countries, mortality declines were shared more equally by educational groups. The increasing mortality among low educated Americans was primarily driven by an increase in mortality from diseases other than cardiovascular diseases or cancer. Because increasing mortality among low educated individuals was only observed in the US and not in Europe, this resulted in even larger educational disparities in mortality in the US than those observed in Europe.

In the second part of this thesis, Chapters 4 to 6, we assessed the contribution of work and family factors, both separately and jointly, in explaining the US health disadvantage. Before examining whether work and family factors played a role in explaining the US health disadvantage, we assessed their relationship with health and mortality. As this relationship is likely to be different for men and women, we explored patterns separately for men and women.

Chapter 4 examined whether family-related factors play a role in explaining educational inequalities in mortality, alongside material, employment-related, and behavioral factors, and whether these explanations differed for men and women. We used data of men and women aged 25 to 74 year who participated in the prospective Dutch GLOBE study (at baseline in 1991) and were linked to almost 23 years of mortality follow-up from Dutch registry data. Educational gradients in mortality were found for both men and women. All factors together explained a substantial part of educational inequalities in mortality for the lowest educated men and women. Yet, type of employment contributed more to the explanation of educational inequalities in all-cause mortality for men than for women, whereas the breadwinner's occupational class contributed more for women than for men. Material and employment-related factors contributed more to inequalities in mortality from cardiovascular disease for men than for women, but they explained more of the inequalities in cancer mortality for women than for men. Hence, gender differences were found in the contribution of employment-related factors – but not of material, behavioral or family-related factors – to the explanation of educational inequalities in all-cause mortality.

In Chapter 5, the interaction between marriage and labor force participation on mortality in the US and 6 European countries – Austria, England and Wales, Finland, Hungary, Norway, and Spain (specifically the Basque country) – was examined. Data from the National Health Interview Survey, linked to the National Death Index, were used for the US, whereas national mortality registry data were used for the European countries. Men and women aged 30 to 59 years were included for the period 1999 to 2007. Labor force inactivity was associated with higher mortality; this association was stronger for unmarried individuals than their married counterparts. Likewise, being unmarried was associated with higher mortality, and this association was stronger for inactive than for active individuals. A significant additive interaction between marriage and labor force activity was found for both men and women. On the multiplicative scale, the interaction was only significant for women. A similar pattern was found across all countries. These findings emphasize the importance of public health and social policies that improve health and well-being of unmarried and inactive men and women. A deeper understanding of the underlying mechanisms is needed for the development of such actions.

Chapter 6 presented a study on the association of work-family life histories between ages 16 and 50 years with cardiovascular outcomes after age 50 for women in the US and Europe. We examined whether less-healthy work-family life histories contributed to the higher cardiovascular diseases prevalence in older American compared with European women. Sequence analysis was used to identify distinct work-family typologies for women born between 1935 and 1956 in the US and 13 European countries. Data came from the US Health and Retirement Study (1992–2006) and the Survey of Health, Aging, and Retirement in Europe (2004–2009). Work-family typologies were similarly distributed in the US and Europe. For American women, being a working lone mother predicted a higher risk of heart disease, stroke, and smoking. For European women, it only predicted a higher risk of smoking. Working lone motherhood was more common and had a marginally stronger association with stroke in the US than in Europe. Simulations indicated that if American women had experienced the same work-family trajectories as European women, their higher stroke risk would only be slightly reduced. Differences in work-family trajectories explained thus only a small fraction of the higher cardiovascular risk of American relative to European women.

In sum, the studies in this thesis demonstrated that larger educational inequalities in health in the US than in Europe contribute to the explanation of the US health disadvantage, but that the distribution of and mortality risks associated with marital status, labor force activity, and work-family trajectories for Americans and Europeans did not contribute to the explanation of the US health disadvantage.

Reducing educational inequalities in health in the US, by improving the health of the lower educated, would help to reduce the US health disadvantage. Other studies have suggested that the larger educational inequalities in health in the US as compared to those observed in Western European countries are due to differences in health care systems, differences in the availability of dangerous prescription drugs and other factors associated with 'deaths of despair', but also rural-urban differences and larger inequalities in material circumstances, residential and racial segregation, and unhealthy behaviors in the US. Therefore, policies that address these factors, specifically those related to improving the health and living circumstances of the lower educated, will likely also help reduce the US health disadvantage.

SAMENVATTING

Vergeleken met individuen uit andere ontwikkelde landen zijn Amerikanen slechter af met betrekking tot hun levensverwachting, zelfgerapporteerde gezondheidsmaten, en sterfte aan vele specifieke doodsoorzaken. Dit wordt vaak in algemene termen 'het Amerikaanse gezondheidsnadeel' genoemd. Dit nadeel is groter voor vrouwen dan voor mannen en is aanwezig gedurende de gehele levensloop. Het (volks)gezondheidssysteem, gezondheidsgedragingen, de fysieke en sociale omgeving en sociale factoren zijn eerder genoemd als mogelijke verklaringen voor het Amerikaanse gezondheidsnadeel. Ondanks dat de verklaring uitgebreid onderzocht is, zijn onderzoekers er nog niet in geslaagd de oorzaken van dit gezondheidsnadeel volledig te identificeren.

Het doel van dit proefschrift was inzicht te krijgen in de rol van sociale ongelijkheid in het verklaren van gezondheidsverschillen tussen de Verenigde Staten (VS) en West-Europese landen, met een specifieke focus op opleidingsniveau en werk- en familiefactoren. In het eerste deel van dit proefschrift, dat bestaat uit hoofdstukken 2 en 3, evalueerden we de bijdrage van ongelijkheid in gezondheid naar opleidingsniveau aan de verklaring van het Amerikaanse gezondheidsnadeel. In hoofdstuk 2 hebben we onderzocht in welke mate grotere opleidingsverschillen in de VS dan in 7 Europese landen – België, Denemarken, Finland, Frankrijk, Noorwegen, Zweden en Zwitserland – de hogere sterfte in de VS verklaren. De Europese data kwamen van volkstellingen die zijn gekoppeld aan gegevens uit sterfteregisters en de Amerikaanse gegevens kwamen van de '*National Health Interview Survey*' die zijn gekoppeld aan informatie van de '*National Death Index*'. We selecteerden mannen en vrouwen tussen de 30 en 74 jaar in de jaren tussen 1989 en 2003. Opleidingsverschillen in gezondheid kunnen op twee verschillende manieren bijdragen aan gezondheidsverschillen tussen de VS en Europa; (1) via verschillen in de verdeling van opleidingsniveau en/of (2) via verschillen in het effect van opleiding op gezondheid. We vonden dat over het algemeen meer Amerikanen een hoger opleidingsniveau hadden dan Europeanen. Als de Amerikaanse bevolking dezelfde verdeling van opleidingsniveau zou hebben gehad als de Europese bevolkingen in de studie, zou het Amerikaanse sterftenadeel groter zijn geweest. Het effect van opleiding op sterfte is echter in de VS groter dan in de Europese landen uit het onderzoek. De sterfteverschillen tussen de VS en Europa zouden daarentegen met 20 tot 100% worden teruggedrongen als het effect van opleidingsniveau op sterfte in de VS hetzelfde zou zijn als die in Europa. Grotere opleidingsverschillen in sterfte in de VS dan in Europa verklaren dus voor een deel waarom Amerikaanse volwassenen een hogere sterfte hadden dan Europese volwassenen. Beleid om sterfte onder lager opgeleiden terug te dringen is nodig om de kloof in sterfte tussen de VS en de Europese landen te overbruggen.

In hoofdstuk 3 onderzochten we veranderingen in sterfteverschillen naar opleidingsniveau over de tijd voor de VS en 7 Europese landen – België, Denemarken, Finland, Italië, Slovenië, Zweden en Zwitserland. Totale en doodsoorzaakspecifieke sterftecijfers naar opleidingsniveau zijn berekend voor de jaren 1990–1995 en 2000–2005, en vervolgens vergeleken tussen de VS en de Europese landen. Gegevens uit sterfteregisters zijn gebruikt voor de Europese landen, terwijl gegevens van de '*National Health Interview Survey*' gekoppeld aan de '*National Death Index*' zijn gebruikt voor de VS. Mannen en vrouwen in de leeftijd van 35 tot 74 jaar in de periode 1989 tot 2006 waren geïncludeerd in de steekproef. Absolute ongelijkheden in sterfte stegen significant meer in de VS dan in de Europese landen als gevolg van toenemende sterfte onder lager opgeleiden, specifiek onder vrouwen. In de Europese landen was de sterftedaling gelijker verdeeld over de verschillende opleidingsgroepen. De toenemende totale sterfte onder laagopgeleide Amerikanen werd hoofdzakelijk veroorzaakt door een toename van sterfte door andere ziekten dan hart- en vaatziekten en kanker. Omdat de toenemende sterfte onder laaggeschoolde individuen alleen in de VS werd waargenomen, zorgde dit voor nog grotere opleidingsverschillen in sterfte in de VS dan de waargenomen verschillen in Europa.

In het tweede deel van dit proefschrift, bestaande uit hoofdstukken 4 tot 6, hebben we de bijdrage van werk- en familiefactoren, zowel afzonderlijk als gezamenlijk, aan de verklaring van het gezondheidsnadeel van de VS onderzocht. Alvorens te onderzoeken of werk- en familiefactoren een rol speelden, hebben we eerst naar de relatie tussen deze factoren en gezondheid gekeken. Omdat deze relatie waarschijnlijk anders is voor mannen en vrouwen, hebben we de patronen apart voor mannen en vrouwen onderzocht.

In hoofdstuk 4 hebben we onderzocht of familie-gerelateerde factoren, naast materiële, werk-gerelateerde en gedragsfactoren, bijdragen aan het verklaren van opleidingsverschillen in sterfte. Tevens hebben we onderzocht of de verklaringen verschillen voor mannen en vrouwen. Gegevens van mannen en vrouwen in de leeftijd van 25 tot 74 jaar bij de eerste meting van de Nederlandse GLOBE (Gezondheid en Leef Omstandigheden van de Bevolking van Eindhoven en omstreken) studie in 1991 zijn gebruikt. Deze gegevens zijn vervolgens 23 jaar later gekoppeld aan sterftedata van het Centraal Bureau voor de Statistiek. We vinden een gradiënt in sterfte naar opleidingsniveau, de kans op sterfte nam af met een toenemend opleidingsniveau, voor zowel mannen als vrouwen. Alle factoren samen verklaarden een substantieel deel van de opleidingsverschillen in sterfte voor de laagstopgeleide mannen en vrouwen. Het type werk droeg meer bij aan de verklaring van opleidingsverschillen in totale sterfte voor mannen dan voor vrouwen, terwijl de beroepsklasse van de kostwinner meer bijdroeg aan de verklaring voor vrouwen dan voor mannen. Materiële en werk-gerelateerde factoren verklaarden meer van de ongelijkheden in sterfte als gevolg van hart- en vaatziekten bij mannen dan bij vrouwen, terwijl ze meer verklaarden van de ongelijkheden in kankersterfte voor vrouwen dan voor mannen. De bijdrage van werk-gerelateerde factoren – maar niet van materiële, gedrags- of familiefactoren – aan de verklaring van opleidingsverschillen in totale sterfte verschilt dus voor mannen en vrouwen.

In hoofdstuk 5 onderzochten we het effect van de interactie tussen getrouwd zijn en arbeidsmarktparticipatie op sterfte in de VS en 6 Europese landen – Engeland en Wales, Finland, Hongarije, Noorwegen, Oostenrijk en Spanje (specifiek Baskenland). Voor de VS gebruikten we gegevens van de '*National Health Interview Survey*' gekoppeld aan de '*National Death Index*'. Gegevens van nationale sterfteregisters zijn gebruikt voor de Europese landen. We hebben mannen en vrouwen in de leeftijd van 30 tot 59 jaar geïncludeerd in de periode 1999 tot 2007. Niet actief zijn op de arbeidsmarkt ging gepaard met een hogere sterftekans; deze relatie was sterker voor ongehuwde dan voor gehuwde individuen. Ongehuwd zijn was geassocieerd met een hogere sterftekans en deze associatie was sterker voor individuen die niet actief waren op de arbeidsmarkt dan degenen die wel actief waren. We vonden dat ongehuwde vrouwen die niet actief waren op de arbeidsmarkt een hogere sterftekans hadden dan we zouden verwachten op basis van de individuele effecten van ongehuwd of inactief zijn. Voor mannen was dit alleen het geval als we naar de opsomming van de effecten keken, en niet naar de vermenigvuldiging. Een vergelijkbaar patroon werd gevonden in de landen waarin dit werd bestudeerd. De bevindingen van deze studie benadrukken het belang van volksgezondheids- en sociaal beleid dat vooral de gezondheid en het welzijn van ongehuwde mannen en vrouwen die niet actief zijn op de arbeidsmarkt verbetert. Meer inzicht in de onderliggende mechanismen is nodig voor de ontwikkeling van dergelijk beleid.

In hoofdstuk 6 beschreven we onderzoek naar de relatie tussen werk en familieleven, gemeten van 16 tot 50 jaar, en cardiovasculaire uitkomsten na de leeftijd van 50 jaar voor Amerikaanse en Europese vrouwen. We hebben onderzocht of een minder gezonde werk-familie levensgeschiedenis heeft bijgedragen aan de hogere prevalentie van hart- en vaatziekten in oudere Amerikaanse vrouwen. Sequentie analyse werd toegepast om verschillende werk-familie patronen van 16 tot 50 jaar te identificeren voor vrouwen geboren tussen 1935 en 1956 in de VS en in 13 Europese landen. Gegevens voor de Amerikaanse vrouwen kwamen van de '*Health and Retirement Study*' (1992–2006) en voor de Europese vrouwen kwamen de gegevens van de '*Survey of Health, Aging, and Retirement in Europe*' (2004–2009). De verdeling van werk-familie patronen was vergelijkbaar voor de VS en Europa. Amerikaanse werkende alleenstaande moeders hadden een hoger risico op hartziekten, beroertes en roken dan Amerikaanse werkende getrouwde moeders. Vergeleken met Europese werkende getrouwde moeders hadden Europese werkende alleenstaande moeders alleen een hoger risico om te roken. Het percentage werkende alleenstaande moeders was hoger in Amerika dan in Europa. Vergeleken met werkende getrouwde moeders hadden werkende alleenstaande moeders een marginaal hogere kans op het krijgen van een beroerte in de VS dan in Europa. Als Amerikaanse vrouwen dezelfde verdeling van werk-familie patronen en dezelfde effecten van werk-familie patronen op gezondheid hadden gehad als Europese vrouwen, dan zou dit hogere risico op beroertes slechts licht afnemen. Verschillen in werk-familie patronen verklaarden dus slechts een klein deel van het hogere risico van

Amerikaanse ten opzichte van Europese vrouwen op hart- en vaatziekten en gerelateerde gedragsfactoren.

Samenvattend laten de studies in dit proefschrift zien dat grotere opleidingsverschillen in gezondheid in de VS dan in Europa hebben bijdragen aan de verklaring van het Amerikaanse gezondheidsnadeel. De verdeling van en sterfterisico's verbonden aan burgerlijke staat, arbeidsmarktparticipatie en patronen van werk- en familiefactoren daarentegen droegen niet bij aan deze verklaring.

Het terugdringen van opleidingsverschillen in gezondheid in de VS, door het verbeteren van de gezondheid van laagopgeleiden, zou het Amerikaanse gezondheidsnadeel verkleinen. Eerdere studies hebben voorgesteld dat de grotere opleidingsverschillen in gezondheid in de VS ten opzichte van die in West-Europese landen, mogelijk het resultaat zijn van verschillen in gezondheidszorgsystemen, de mate waarin factoren voorkomen die samenhangen met 'wanhoop-gerelateerde sterfte', en grotere ongelijkheden in materiële omstandigheden, residentiële en rassensegregatie en ongezond gedrag in de VS. Beleidsmaatregelen om deze factoren aan te pakken, met name de factoren die verband houden met het verbeteren van de gezondheid en leefomstandigheden van lager opgeleiden, zullen waarschijnlijk ook bijdragen aan een vermindering van het Amerikaanse gezondheidsnadeel.

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Enrique Regidor Department of Preventive Medicine and Public Health, Universidad Complutense de Madrid, Madrid, Spain

Erika L. Sabbath Harvard Center for Population and Development Studies, Harvard School of Public Health, Cambridge, MA, US; School of Social Work, Boston College, Chestnut Hill, MA, US

LIST OF PUBLICATIONS

Y. Hu, T. Leinonen, **K. van Hedel**, M. Myrskylä, and P. Martikainen. "The relationship between living arrangements and higher use of hospital care at middle and older ages: To what extent do observed and unobserved individual characteristics explain this association?" (2019). *BMC Public Health.* 19:1011.

K. van Hedel, F.J. van Lenthe, J. Oude Groeniger, and J.P. Mackenbach. "What's the difference? A gender perspective on understanding educational inequalities in all-cause and cause-specific mortality." (2018). *BMC Public Health*. 18:1105.

K. van Hedel, P. Martikainen, H. Moustgaard, and M. Myrskylä. "Cohabitation and mental health: Is psychotropic medication use more common in cohabitation than marriage?" (2018). *SSM - Pop Health*. 4:244–253.

Y. Hu, F.J. van Lenthe; R. Hoffmann, **K. van Hedel**, and J.P. Mackenbach. "Assessing the impact of natural policy experiments on socioeconomic inequalities in health: how to apply commonly used quantitative analytical methods?" (2017). *BMC Med Res Methodol*. 17(1):68.

K. van Hedel, I. Mejía-Guevara, M. Avendano, E.L. Sabbath, L.F. Berkman, J.P. Mackenbach, and F.J. van Lenthe. "Work-family trajectories and the higher cardiovascular risk of American women relative to women in 13 European countries" (2016). *Am J Public Health*. 108(8):1449–1456.

K. van Hedel, F.J. van Lenthe, M. Avendano, M. Bopp, S. Esnaola, K. Kovács, P. Martikainen, E. Regidor, and J.P. Mackenbach. "Marital status, labour force activity and mortality: A study of the United States and 6 European countries." (2015). *Scand J Public Health*. 43(5):469–480.

K. van Hedel, M. Avendano, L.F. Berkman, M. Bopp, P. Deboosere, O. Lundberg, P. Martikainen, G. Menvielle, F.J. van Lenthe, and J.P. Mackenbach. "The contribution of national disparities to international differences in mortality between the United States and 7 European countries." (2015). *Am J Public Health*. 105(4):e112–e119.

PHD PORTFOLIO

PhD student:	Karen van Hedel
University:	Erasmus Universiteit Rotterdam
Faculty:	Erasmus MC
Department:	Public Health
PhD period:	2011 – 2015
Promotors:	Prof.dr. F.J. van Lenthe Prof.dr. J.P. Mackenbach Prof.dr. M. Avendano

	Year	Workload
Classes taken at Erasmus University Medical Center, Rotterdam (NIHES)		
Causal inference	2013	0.7 ECTS
Survival Analysis	2013	1.9 ECTS
Other courses		
Summer School on Longitudinal and Life Course Research, Department of Sociology, University of Oxford, Oxford, United Kingdom	2013	2.0 ECTS
Quantitative Methods for Public Policy Evaluation, Microeconometrics Summer School, Barcelona GSE, Graduate School of Economics, Barcelona, Spain	2012	2.0 ECTS
Oral presentations at conferences		
The Population Association of America Annual Meeting, San Diego, USA – Mortality trends by education in the United States and Europe.	2015	1.0 ECTS
The Population Association of America Annual Meeting, Boston, USA – Do work-family patterns over the life-course influence health at old age? A sequence analysis approach across 13 European countries and the United States	2014	1.0 ECTS
The Dutch Conference on Public Health (Nederlands Congres Volksgezondheid), Rotterdam, the Netherlands – The relation between combining work and care tasks and health outcomes (De relatie tussen het combineren van werk- en zorgtaken en gezondheidsuitkomsten).	2014	1.0 ECTS
The 4th SHARE User Conference, Liège, Belgium – Do work-family patterns over the life-course influence health at old age? A sequence analysis approach across 13 European countries and the United States.	2013	1.0 ECTS
The Population Association of America Annual Meeting, New Orleans, USA – The contribution of larger educational inequalities in the mortality to the national mortality disadvantage of the United States. A comparison with seven Western European countries. – The protective effect of marriage and labor force participation on mortality. A comparison between the United States and five European countries.	2013	2.0 ECTS

Oral presentations at project meetings

Social Protection project meetings: Cambridge (MA, USA), Paris (France), Munich (Germany)		6.0 ECTS
– Do work-family patterns over the life-course influence health later in life? A sequence analysis using SHARE and HRS.	2015	
– Do work-family patterns over the life-course influence health later in life? A sequence analysis using SHARE and HRS; and Linking work-family strain and health in a longitudinal framework. Using 3 waves for France from the Generations and Gender Survey.	2014	
– Two approaches to measuring work-family strain. Using the GLOBE data.	2013	
– The protective effect of marriage and labor force participation on mortality. A comparison between the United States and five Western European countries.	2013	
– The contribution of larger educational inequalities in mortality to the national mortality disadvantage of the United States.	2012	
– Educational differences in mortality; and Marital status, employment and mortality.	2012	
Research meetings of the Department of Public Health and of the Social Epidemiology section, Erasmus University Medical Center, Rotterdam, the Netherlands		2.0 ECTS
– Marital status, labor force activity and mortality. A study of the United States and 6 European countries.	2014	
– Do work-family patterns over the life-course influence health later in life?	2014	
– The contribution of larger educational inequalities in mortality to the national mortality disadvantage of the United States.	2012	
– The causal effect of first occupation on health. Selection into occupations, an intuitive explanation.	2012	

Attendance at conferences, workshops, seminars and symposia

Research meetings and seminars of the Department of Public Health, Rotterdam, the Netherlands	2011–2015	2.0 ECTS
Population Association of America Annual Meetings		
– San Diego, CA, USA	2015	0.8 ECTS
– Boston, MA, USA	2014	0.8 ECTS
– New Orleans, LA, USA	2013	0.8 ECTS
Dutch Conference on Public Health (Nederlands Congres Volksgezondheid), Rotterdam, the Netherlands	2014	0.2 ECTS
4th SHARE User Conference, Liège, Belgium	2013	0.4 ECTS
Health and inequality across the life cycle: Employment and behavioral pathways, Netspar workshop, Rotterdam, the Netherlands	2012	0.3 ECTS
From before the cradle to the grave – Methodological challenges in life course epidemiology, WEON preconference workshop, Rotterdam, the Netherlands	2012	0.1 ECTS

International research projects

International research project at Institut National d'Études Démographiques, Paris, France	2014	10.0 ECTS

Other

Reviewed articles for *International Journal of Epidemiology*, *PLOS ONE*, *Public Health*	2014–2015	

Teaching activities

'The causal effect of first occupation on health. Selection into occupations, an intuitive explanation', Hot topic as part of the course "Public health research: Analysis of determinants", NIHES, Rotterdam, the Netherlands	2012–2014	1.5 ECTS
Supervising public health community project of third year medical students, part of the education theme 3.C "Arts en volksgezondheid" at Erasmus University Medical Center, Rotterdam, the Netherlands	2013	0.5 ECTS