The Historical Origins of the Mortality Gradient

Socioeconomic Inequalities in Adult Mortality over Two Centuries in Sweden

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2020

Document Version:
Publisher's PDF, also known as Version of record

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Socioeconomic Inequalities in Adult Mortality over Two Centuries in Sweden

Enrico Debiasi

LUND
UNIVERSITY

DOCTORAL DISSERTATION

by due permission of the School of Economics and Management,
Lund University, Sweden.
To be defended at EC3:210 on Friday October 2 2020 at 10:15.

Faculty opponent
Andrew Hinde

Organization	Document name
LUND UNIVERSITY	DOCTORAL DISSERTATION
Department of Economic History	Date of issue 2020-09-10
Author: Enrico Debiasi	Sponsoring organization

Title and subtitle

Title: The Historical Origins of the Mortality Gradient: Socioeconomic Inequalities in Adult Mortality over Two Centuries in Sweden

Abstract

Mortality differentials by socioeconomic status (SES) are among the most pervasive facts of contemporary demography. However, while the mortality gradient by income, class and education is well-established for the period after 1970, evidence regarding the origins of the gradient is still scarce. The aim of this thesis is to explore the development of SES differences in all-cause and cause-specific adult and old age mortality over the last 200 years, exploiting unique longitudinal individual-level data for a regional population in the south of Sweden, as well as full-count decennial microcensuses for the whole country. It was confirmed throughout all the four studies that the socioeconomic gradient in mortality is a recent phenomenon starting after the second world war. This result was independent from the dimension of socioeconomic status used in the analysis. A similar late emergence of social differences in mortality dating back to not earlier than the 1950s is evident regardless of whether the analysis was based on social class or income. Even when examining more detailed occupations, more prestigious jobs such as architects, engineers, physicians, and lawyers were not associated with lower mortality before the second half of the twentieth century. Analyzing more specific groups of diseases showed that the advantages related to one's higher social class or to one's higher income appeared at approximately the same time and did so regardless of preventability. Interestingly, when looking at mortality from circulatory diseases for men both by social class and income during the nineteenth and first half of the twentieth century a reversed gradient emerged. Moreover, empirical models including both social class and income showed that they are both independently related to mortality and that the income gradient appeared at an earlier stage, around the 1950s, while when looking at social class it emerged a couple of decades later. When the relation between social class and mortality is broken down in more detailed occupations, results showed significant differences in mortality by occupation within the same social class. Eventually by analysing the different role of cohort and period effects on the relation between social class and mortality it emerged that cohort factors may have had a greater contribution to explaining mortality patterns by social class. Several mechanisms were considered as possible explanations for such patters, including early life factors, material resources and lifestyle. Taken together the results point toward the importance of lifestyle factors. Such mechanism is consistent with the reverse gradient in circulatory diseases before the 1950s and the turn-around that happened later. Indeed, higher social classes were more likely to be heavy consumers of alcohol, to smoke tobacco and to have a sedentary life. In more recent years, the opposite is true. Moreover, unhealthy behaviors were more common among men, which is a potential explanation for why the reverse gradient is not present for women. Overall, the studies presented here looking at long-term developments of the SES-mortality relation reveal that the impact of SES on survival chances has not always been the same but it rather depends on which coping mechanisms each SES group exploits to avoid risk factors at each point in time.

Key words: socioeconomic status, social class, income, adult cause-specific mortality, Sweden, long-term development

Classification system and/or index terms (if any)

Supplementary bibliographical information		Language: English
ISSN and key title 1400-4860		ISBN 978-91-87793-66-0
Recipient's notes	Number of pages 305	Price
	Security classification	

Signature  Date 2020-09-10

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Lund Studies in Economic History is a series of doctoral dissertations and edited volumes of high scholarly quality in subjects related to the Department of Economic History at the School of Economics and Management, Lund University. All volumes have been reviewed and approved prior to publication.

Coverphoto by Elisa Tiozzo Fasiolo

School of Economics and Management

Department of Economic History

ISBN 978-91-87793-66-0 (print)

ISBN 978-91-87793-67-7 (pdf)

ISSN 1400-4860

Printed in Sweden by Media-Tryck, Lund University

Lund 2020

To my Mom and Dad

[...] Non c'era niente che potesse evitare il conflitto tra i ricchi e i poveri.

Perché?

Quelli che stanno sotto vogliono andare sopra, quelli che stanno sopra vogliono restare sopra, e in un modo o nell'altro si arriva sempre a prendersi a sputi e a calci in faccia

Proprio per questo il punto è risolvere I problemi prima che si arrivi alla violenza

E come? Portando tutti sopra, portando tutti sotto?

Trovando un punto d'equilibrio tra le classi

Un punto dove? Quelli di sotto s'incontrano a mezza strada con quelli di sopra?

Diciamo di si

E quelli di sopra scendono di sotto volentieri? E quelli di sotto rinunciano ad andare più su?

Se si lavora a risolvere bene tutte le questioni, si. Non sei convinta?

Elena Ferrante, L'amica geniale

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Aknowledgements

It feels quite good to be writing the acknowledgments as, even though they are at the beginning of the book, it means that all the rest of the thesis is completed. Although it sounds obvious, to me one of the toughest aspects of these four years was accepting that, as Rome wasn't built in a day, neither is a scientific paper. I wanted everything perfect straight away, but between the first draft and a somewhat final version of an article there is a lot of writing and adjusting and extending and cutting and rewriting. Sometimes I felt a bit lost, but luckily I could count on the support of friends and colleagues. So, I would like to acknowledge all those who gave me precious help me along the way.

First and foremost I want to thank my supervisor Martin Dribe. I am extremely grateful for many things. Firstly, for giving me the chance of pursuing a PhD degree, which was something that I really wanted to do. Then, for all the guidance towards proper academic research. Not only you gave me great comments to improve my work, but you have also been an endless source of knowledge and above all an exemplary academic figure to look up to. Thanks for giving me my first opportunity to teach. And thanks for taking the time for reading everything I sent you in these years regardless of the quality and for giving me careful and constructing feedback.

Thanks to my co-supervisor Luciana Quaranta for all the help with my papers, with STATA and especially with the data. Thank you for always taking the time to discuss with me whatever question I had after barging in to your office without notice. I am also really grateful for all your encoruragement throughout the process.

I was lucky enough to be part of the LONGPOP project funded by the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 676060. Since the very beginning I was given the chance to participate in incredibly interesting and at the same time fun activities. Additionally it gave me a unique opportunity to create a network of fellow researchers. I am grateful to Diego Ramiro Fariñas for leading the project and always trying to make sure that the needs of us early stage researchers were met. Also I would like to thank Lucia Pozzi, Marco Breschi, and the other colleagues in Sassari as well as Angelique Janssens, Jan Kok, and the group in Nijmegen for welcoming me and for the great time I had during the two exchange periods. Alghero became my favorite place on earth and I will always look forward to go back to Nijmegen and its friendly vibe. I want to thank all my LONGPOP colleagues

and in particular Matthias and Gergö for all the nice memories and interesting discussions from our meetings and for becoming good friends.

Since the very beginning, when I arrived in Lund, I was welcomed in a great working environment. A huge thank you for the patience and the unvaluable help to Anneli Nilsson Ahlm, Kristin Fransson, Madeleine Jarl, Tina Wueggertz and Christina Rothman. I would like to thank the head of the Department of Economic History, Mats Olsson and the current and previous Directors of Graduate Studies, Patrick Svensson and Astrid Kander for helping me during all the PhD process. Also thanks to the Centre for Economic Demography that allowed me access to the data which development was funded by the Swedish Foundation for the Humanities and Social Sciences (RJ) within the Landskrona Population Study research program.

Being at the Department of Economic History gave me the privilege to work with and learn from incredible people. In particular, I would like to thank Björn Eriksson for all the sharp feedbacks and the fruitful conversations. Thanks to Tommy and Ingrid for all the nice discussions and particularly for taking the time to read the earlier draft of this book and giving me precious feedback at my final seminar. Thanks to Kirk for helping me navigating academic conferences and for trusting me with the teaching of the econometrics labs.

A special thanks to Sid for not stop talking to me after I made that bus ride in Bornholm pretty boring and for always inspiring with so many new ideas for the next paper and, I must say, for showing me the art of networking at meetings and conferences. Thanks for becoming such a good friend, I really learned a lot from you and I am looking forward to keep working together on new projects and to a lot of fun together.

I would like to thank Elien, Luis and Martin Ö. for sharing nice lunches, discussions about the most disparate topics, but mostly I thank you for sharing with me all the daily frustrations as well as the daily joys at the office throughout these years. Also thanks to Finn and Gabriel for the nice time and the football games played together.

Help comes in many shapes and forms and if I made it to the end it is also for the fun and relaxing times I had when going back to Italy to see my lifetime friends Andrea, Luca and Lorenzo. Thank you for the always-too-little time that we spend together and for always being there.

Thanks to my friends in Stockholm, Elisa (who designed the amazing cover of this book) Simone, Alessandro, Elena, Elisa, and Erik for all the nice meals, trips, and laughs together and for being the kindest judges of my recipes.

I also want to thank old friends from university Max, Elias, Robert, and Alex for keeping in touch even though we all live in different countries. I always look forward to catching up with you.

I want to thank my parents for being an ever present source of encouragement to study and to follow my interests. There is no way to express how grateful I am for all the support you gave throughout the years. Also thanks to my sister for always being there and being constantly interested and excited about what I do eventually providing a boost in my energies.

Thanks to Rita for always welcoming me so warmly, for the great food that we always find every time that we go back home and for everything you do for us.

Finally, I want to thank Laura. It is complicated if not impossible to thank you enough in just a few lines. Thank you for all the help with making my long and convoluted sentences readable, for all the help in making sense of statistics and, above all, thank you for making every moment so special and for the love and happiness that we share together. Now, what's next?

List of paper

I. Debiasi, Enrico; and Dribe, Martin (2020). SES Inequalities in Cause-Specific Adult Mortality: a Study of the Long-Term Trends Using Longitudinal Individual Data for Sweden (1813-2014). *Unpublished manuscript*.

II. Debiasi, Enrico; Dribe, Martin; and Brea Martinez, Gabriel (2020). Has it Always Paid to be Rich? Income and Cause-Specific Mortality in Southern Sweden 1905-2014. *Unpublished manuscript*.

III. Debiasi, Enrico (2020). Differences in All-Cause Adult Mortality by Occupation Using Full-Count Data from Sweden, 1880-2001. *Unpublished manuscript*.

IV. Debiasi, Enrico (2020). Period and Cohort Trends in Social Class Inequalities in Adult Mortality: Evidence from Southern Sweden 1905-2014. *Unpublished manuscript*.

Introduction

Motivation and aim

Health is the result of a series of complex interactions among several influences, such as genetics and biology but also social and environmental factors. Some of these elements could be the result of random events, or events that the scientific community has not yet understood and described; others could be the consequences of well-known processes. Public health policies have been developed over the years and are frequently updated based on the best available evidence, for the purpose of acting on well-known risk factors for diseases. The implementation of different prevention and treatment interventions aims at guaranteeing the right to be in good health. However, while being in good health is universally valued, it is also widely acknowledged that the chances of being healthy are not equally distributed across different populations and across different groups within the same populations. In fact, with remarkable consistency across studies that have looked at different contexts over the last half century, social factors have been found to be one of the main discriminatory forces. For a variety of reasons and according to several indicators, as will be further explored below, individuals who are better positioned in society can look forward to a considerably longer and healthier life expectancy than people in more disadvantaged groups.

A man who is 35 years of age and in the richest 20% of the income distribution in Sweden can expect to live over 9 years longer than a man in the poorest quintile; for women, this difference is 2 years less (see Figure 1). The gap between the top and the bottom of the income distribution has been increasing over time. For men, their life expectancy at 35 in the top quintile increased by 4.4 years in the two decades between 1986 and 2007, while the increase for the poorest fifth of the income distribution was 2.7 years (Hederos et al., 2018). For women, in the same period, the gain in life expectancy in the bottom quintile was 1.4 years, compared to 2.6 years in the highest income group (Hederos et al., 2018).

A striking feature of such differences in life expectancy is that they are not only apparent when comparing groups at the extreme ends of the distribution. There is instead a gradual increase in life expectancy when going from a certain income level to the income level above. While it is evident when using larger income groups, such as in Figure 1, the trend is also manifested with a more granular division of the distribution, as in Figure 2.

Figure 1: Life expectancy at 35 by family income quintile in Sweden, 1980-2007
Source: Adapted from (Hederos et al., 2018)

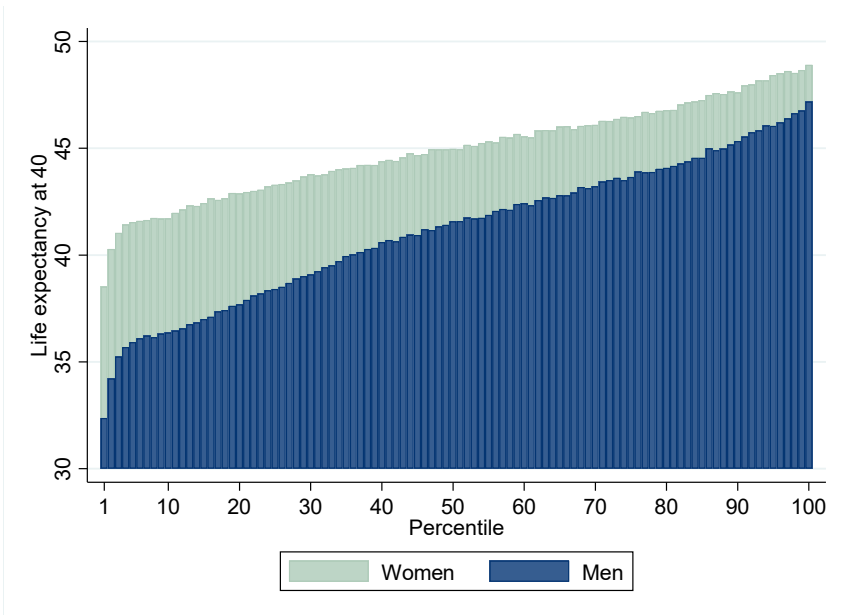


Figure 2: Life expectancy at 40 by household income percentile in the United States
Source: The health inequality project (healthinequality.org; see also Chetty et al., 2016)

Interestingly, such an association with longevity is not found only when considering the financial resources (i.e., income or wealth), but it is also present when using other indicators of socioeconomic status (SES), such as education and social class. An increasingly higher mortality is found when moving from university educated individuals to high school and primary education (e.g., Glied & Lleras-Muney, 2008; Lleras-Muney, 2005). The same trend holds when shifting from the top to the bottom of the social ladder (based on occupation). A prominent example comes from the Whitehall studies in the United Kingdom that investigated mortality among civil servants; these revealed that the length of life is lengthened from one employment grade to the next (e.g., Marmot et al., 1984, 1991; Marmot & Shipley, 1996). Such a pattern of association with longevity using multiple indicators of SES is what has been commonly referred to as the SES gradient in health and mortality.

SES inequalities in health and mortality are one of the most important public health challenges and pressing issues for policy makers (Healthy People 2020, 2011; Lewer et al., 2020; WHO, 2008). In England, for example, one out of three premature deaths (i.e., before 75 years of age) is attributable to SES differences (Lewer et al., 2020). Addressing social differences in mortality is not limited to being a moral matter; instead, taking action against those differences could lead to potentially large economic benefits (Marmot et al., 2014). While a precise estimation of the economic impact of health inequalities is difficult, in the European Union, welfare losses linked to health inequalities amount to 980 billion euro every year, which corresponds to 9.4% of the GDP (Mackenbach et al., 2011). In the United States (US), the yearly economic value that would derive from improving the health of lower educated individuals to the health of college graduates is estimated to be $1.02 trillion (Schoeni et al., 2011).

Naturally, a large amount of effort from researchers has been focused on understanding the factors that lie at the basis of the relation between social standing and health and mortality. SES is an encompassing term that usually indicates one or more measures, among which are income, education, and social class. In addition to being related to one another, each of these measures is connected to health and mortality through a wide and complex array of mechanisms, which include medical care access, material resources, life style, and social networks (Cutler et al., 2006; Cutler et al., 2012; Elo, 2009). To implement effective and efficient policies, such mechanisms must be well understood, and one important way to deepen the understanding is to look at the development over time. Much of the research about socioeconomic differences in mortality is focused on a period that usually covers the past 30-40 years. Such literature has greatly contributed to establishing the connections between SES and health. However, studies that look at long-term trends are rare, and our understanding about whether socioeconomic differences have always been there or when they have started to emerge is limited.

Sweden is an interesting case for studying social differences in mortality. On the one hand, throughout the twentieth century, it has been at the forefront in terms of

welfare policies that are aimed at equality and universalism. A wide array of social policies has been developed, including free education and universal access to health care. On the other hand, however, several comparative studies that consider a number of European countries have found that health inequalities are not the smallest in the Nordic welfare regimes (Eikemo et al., 2008, 2008; Mackenbach et al., 1997, 2009). This aspect of SES differences in health has been labeled as a "public health puzzle" (Bambra, 2011) and the "Nordic paradox" (Mackenbach, 2012, 2017).

Several explanations have been proposed. First, in simple terms, it could be the case that welfare policies have not completely eliminated the disparities in the access to material and immaterial resources. Social selection is another possible explanation, with people being selected into SES groups based on their health status or health determinants (direct and indirect selection). If this circumstance was the case, then it would mean that poor health would lead to much worse social consequences in the Nordics than in other welfare regimes. However, the fact that the unemployment and disability protections are relatively higher in such countries makes social selection more unlikely. Alternatively, it could be a consequence of a cultural-behavioral component that would lead to health inequalities by SES as a consequence of the differences in health-related behaviors, with lower SES groups being more exposed to unhealthy habits. More specifically, if unhealthy behaviors are more socially stratified in the Nordics than in other countries – as appears to be the case, for example, for smoking (Dahl et al., 2006; Mackenbach et al., 2009) – then this stratification could explain the persistence of inequalities (for a summary of explanations, see Bambra, 2011 and Mackenbach, 2012). Nevertheless, recent reviews on the matter have concluded that the evidence is still scarce and inconsistent (Beckfield & Krieger, 2009; Muntaner et al., 2011).

Essentially, what emerges is the fact that the mechanisms that drive SES inequalities in health and mortality are still not well understood. One way to deepen our understanding of such disparities is to take a long-term perspective and fill in the knowledge gap that is related to how the relation between social standing and health has developed over time and resulted in the gradient that is widely observed today. Taking a historical look at the relation provides new insights into the mechanisms by comparing, for example, how the relation between SES and mortality developed in a changing epidemiological environment. A historical perspective that is highly focused on Sweden could further shed light on the possible pathways by discussing the development of the association in an environment that is characterized by expanding welfare policies in support of a more equal society. According to Sundin and Willner (2007, p. 18), who rationalize taking a long-term, historical approach, "*Each context is to a great extent unique and history cannot provide readymade solutions to contemporary problems. Nevertheless, there may also be some lessons and food for constructive thought to be found for policy makers, through the comparison of one historical period and geographical area with another*".

The aim of this thesis is to provide a detailed account of the development of socioeconomic inequalities in all-cause and cause-specific adult mortality over the past two centuries in Sweden. Empirical analyses are based on unique microlevel data, including different demographic and economic variables, such as different indicators for individuals' SES (social class, income, occupation). More specifically, this thesis consists of four research articles in which the following research questions are addressed:

(1) When did the mortality gradient by SES emerge?

This aspect will be the underlying thread and the common theme that will be examined from different perspectives throughout the following chapters.

(2) How does the relation between the SES and mortality over time vary by the cause of death?

(3) What are the differences in the SES-mortality association when using different indicators (i.e., social class, income)?

Research questions two and three characterize the first two studies. The first study looks at the social class differences in all-cause and cause-specific adults and old age mortality for both men and women living in Southern Sweden, for which individual-level longitudinal data is available from 1813 to 2014. Using different levels of classifications for social class, it provides new evidence with regard to the SES association with cause-specific mortality over a long period of time.

Exploiting income information that is available for individuals living in the above-mentioned area from the early years of the twentieth century, the second paper investigates the emergence of the income gradient for all-cause mortality as well as for specific causes of death between 1905 and 2014. This paper also considers potential differences in the association with mortality levels of income and social class.

Considered together, the first two studies also shed light on how income and social class are differently associated with mortality in different historical times. This will provide further understanding of how the two indicators are independently related to survival chances.

The following paper analyzes in further detail the relation between social class and mortality, tackling the following question:

(4) What is the role of specific occupations in the relation between social class and mortality?

The third study, then, investigates how the relation between specific occupations and mortality changed from the late nineteenth century until the 2000s. The aim of this study is to consider in more detail the differences in the mortality *within* broad occupational social classes. To do so, the analyses are based on full count Swedish

censuses, which provide microlevel information for all individuals living in Sweden that were conducted every 10 years as early as 1880.

In the last chapter, the cohort and period effects on the relation between social class and mortality are analyzed using the data from Southern Sweden, to answer the following question:

(5) To what extent has the development over time been influenced by the period and the cohort factors?

The rationale behind the use of different data sources resides in which available source is more appropriate to address the different research questions. More specifically, the decision is a trade-off between more detailed information for a longer time span and a smaller sample, on the one hand, and a smaller number of variables observed in only certain years but a larger sample, on the other hand. The longitudinal individual-level data available for southern Sweden are perfectly suited for studies one, two, and four, because those data provide a longer time frame and more detailed information (e.g., income information) with respect to the censuses. However, the larger sample provided by the censuses is required to be able to effectively analyze a wider array of specific occupations, as in the third study.

Background and previous research

There is no doubt that the gain in life expectancy that took place over the past two centuries is one of the greatest achievements of humankind. As stated by Riley (2001): *"No grand hope that humankind has held has come so close to fulfilment as the hope that all people will enjoy a long and healthy life."* Staggering is also the steady and linear fashion that characterized such an increase in life expectancy at birth of approximately three months every year from the mid-nineteenth century and throughout the twentieth century (Oeppen & Vaupel, 2002). A Swedish woman born in the 1850s could expect to live 44.5 years, and at the end of the 1990s, almost 82 years (SCB, 1999). The way in which life expectancy has developed in different social classes is, however, an open question.

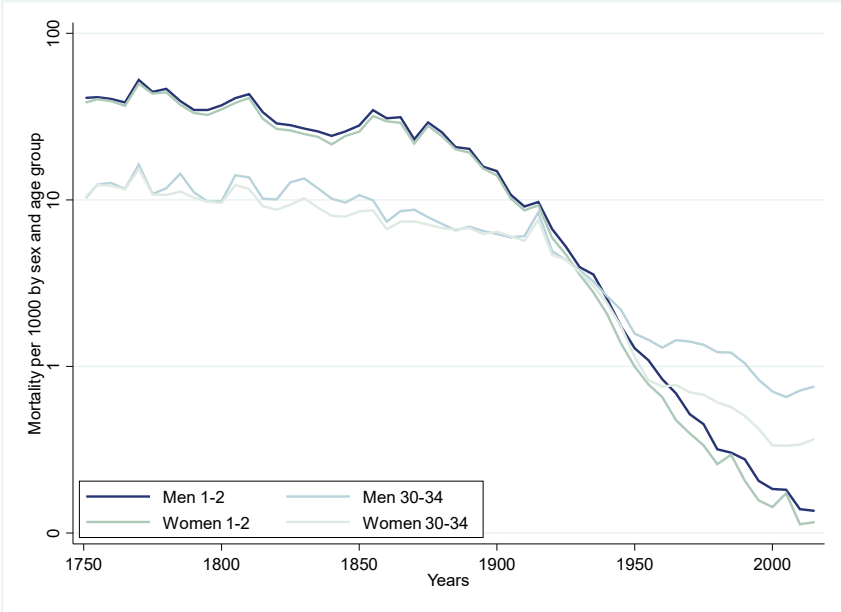


Figure 3: Mortality per 1000 by sex and age group 1751-2015 (5-year intervals).
Source: Human Mortality Database.

Data availability and quality is very high in Sweden and in other Nordic countries today, as in the past. For Sweden, mortality figures go as far back as 1750 (see Figures 3 and 4). This circumstance constitutes a unique opportunity for demographers to study the timing of the mortality decline and to make cross-country comparisons at least for the period from the mid-eighteenth century onward. In addition to macrolevel data, the continuous digitalization efforts of historical parish registers that originated a few decades ago gave researchers access to microlevel information as early as the nineteenth century, allowing them to study aspects of mortality inequalities with a finer level of detail. The following sections will review theories about the determinants of the mortality decline and the current state of the literature in terms of the theories and empirical findings about the socioeconomic differences in adult mortality over the past two centuries.

Determinants of mortality decline

Overall, in the Western world, mortality started to decline during the nineteenth century. This era marks the beginning of the demographic transition and the increase in population size (Davis, 1945). It is well established that the decline started first at earlier ages, with a reduction of infant and child mortality, with different onsets depending on the country (Corsini & Viazzo, 1997). In Sweden, for example, it

started in the first decades of the nineteenth century, which was relatively earlier than in other European countries (Brändström, 1997). Adult and old age mortality decline started later in the nineteenth century, and it became evident only in the twentieth century (Bengtsson, 2015).

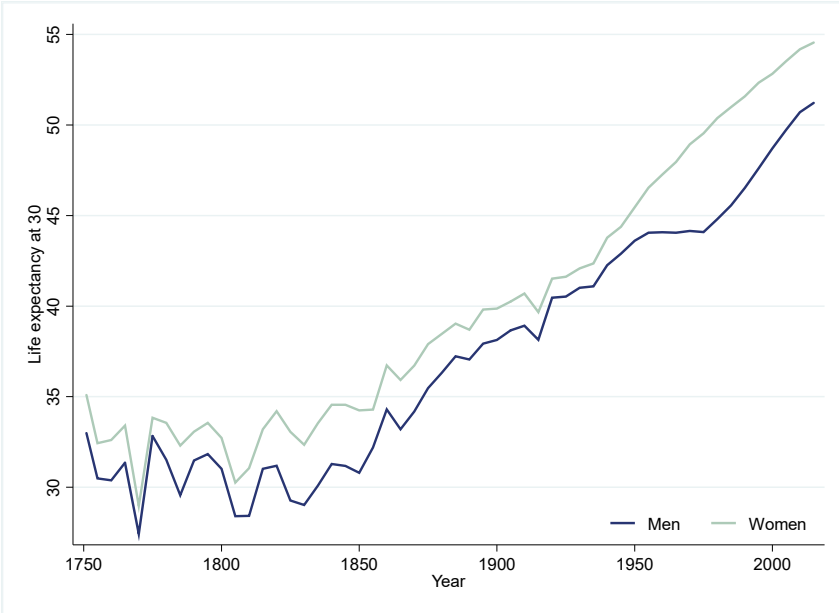


Figure 4: Life expectancy at 30 years old in Sweden 1751-2015 by sex (5-year intervals).
Source: Human Mortality Database.

Another important phenomenon was the change in the disease environment, with a decreasing severity and frequency of pandemic outbreaks, as well as wars and harvest failures, which is reflected also in the second characteristic of the mortality decline, namely, the gradual disappearance of strong fluctuations in mortality levels year after year (see Figure 4). Several factors have been proposed as determinants of the declining rate in mortality. The most discussed in the literature are improved nutrition, public health measures, medical advancements, and better early life conditions (for a review, see Cutler et al., 2006).

In arguing about the demographic transition and in particular about the mortality decline, Davis (1945) pointed at a more abundant, varied and stable food supply that was likely a consequence of improved agricultural techniques and better commerce and transportation. McKeown and Fogel are among the scholars who argued the most in favor of nutrition as a mechanism for the mortality decline (Fogel, 2004; McKeown, 1976). According to McKeown, most of the mortality decline from the mid-nineteenth century until the 1970s was driven by the dramatic decline in

infectious diseases, and in support of his nutritional argument, he observed that death from tuberculosis (and other infectious diseases) sharply declined well before there was any treatment for it (McKeown, 1976; McKeown et al., 1972). Even after other possible explanations, such as reduction in exposure through isolation or less overcrowding, public health measures such as water and sewage systems, improved personal hygiene, and medical treatments, are accounted for, nutrition still explains half of the mortality decline (McKeown, 1976). In discussing the nutritional argument, Fogel showed that from the eighteenth century until the end of the 1990s, the daily caloric supply grew substantially (Fogel, 2004; p. 9). Moreover, people not only gained access to a higher quantity of food but also to a higher quality: until 1850, the share of calories from animal food in France and England was between 20 and 30%, which is less than half of the modern figure (Fogel, 2004; p. 9). At the same time, using height as an indirect measure of improved nutrition, Fogel reported that approximately during the same time span (i.e., 1750-1975), stature increased by approximately 10 centimeters in several European populations, such as Great Britain, France, and the Scandinavian countries (Fogel, 2004; p. 13). Eventually, he concluded that 90% of the mortality decline that took place from the last quarter of the eighteenth century and from the mid-nineteenth century was due to improved nutrition, which accounted for 50% of the mortality decline afterward (Fogel, 1997; p. 471). It is worthwhile to note, however, that Fogel's work is based on the concept of "net nutrition". Different from gross nutrition, net nutrition constitutes what is available for the development of cells after other life supporting nutritional claims (needs) – including nutrients for work and other activities as well as nutrients necessary to recover from infectious diseases – are satisfied (Fogel, 1986). Given that the net nutrition considers both the role of food intake and exposure to disease, it becomes more challenging to distinguish whether health improvements are a consequence of better diet or fewer claims for recovery from infections. Nevertheless, height and gross consumption followed similar trends (Fogel, 1994; Fogel, 2004), which suggests a minor impact of other claims and possibly justifies the focus on gross nutrition.

Additionally, the net nutrition is one of the principal factors when considering what Bengtsson (2015) refers to as cohort explanations or, in other words, "*features that initially affected only certain young age groups but that may have long-lasting effects for the groups involved*". The idea is that exposures to adverse events, such as poor nutrition or infectious diseases, in early life or even during the prenatal period can have a significant detrimental effect on health and mortality later in adulthood and old age (for a review, see Elo & Preston, 1992). As Barker (1990) proposed in the fetal origin hypothesis, early life exposure could mean as early as in the womb (see also Barker, 1994). As a consequence, a portion of the mortality decline in the late twentieth century might be explained by nutritional (but also public health) improvements that took place much earlier in time (Cutler et al., 2006). Fogel (2004) has been an outspoken advocate for the impact of nutrition during childhood on later life health. More specifically, he argued that

undernourishment due to either lower quantity or quality of food intake leads to lower height and weight in adulthood, and it increases the risk of poor health and mortality. For Sweden, Bengtsson and Lindström (2000; 2003) (see also Quaranta, 2013, 2014) used indirect measures of disease exposure and nutrition, looking at short-term fluctuations in infant mortality rate and grain prices. More specifically, they showed that exposure to a high disease load in infancy had a strong effect on later life mortality. To have a better idea of the effect of malnutrition in utero on health later in life, a more precise empirical approach has been to analyze children who were in utero when a famine hit. Crop failures and subsequent famine in Finland between 1866 and 1868 was not associated with adult survival (Kannisto et al., 1997). Similarly, a lack of association between famine in utero and later life health was found when studying the Leningrad siege during World War II (Stanner et al., 1997). The famine from the Dutch hunger winter between 1944 and 1945 is another interesting natural experiment that allows us to compare children who were exposed in utero during the prenatal period to those born before or after the famine. It was found that exposure to the famine was linked to some measures of decreased glucose tolerance (Ravelli et al., 1998), to obesity for women 50 years or age (Ravelli et al., 1999), but not to adulthood blood pressure (Roseboom et al., 1999)(for a review see Lumey & van Poppel, 2013, and Rasmussen, 2001). In terms of later life mortality, a long-term effect of prenatal exposure to the Dutch famine could not be established (Painter et al., 2005). Eventually, in an extensive review about the link between prenatal famine and different adult health measures, it was concluded that a consistent association was found only for adult body size, diabetes and schizophrenia (Lumey et al., 2011). Thus, while the theory has some empirical confirmation, the magnitude of the effect is still debated, and overall, it appears that the effects of nutrition in utero on later life mortality are small compared to exposures in adulthood (Cutler et al., 2006).

Even though nutrition can provide a compelling explanation, several inconsistencies have raised doubts. First, when looking at the life expectancy in England in the period 1500-1700 separately by social class, which had different levels and qualities of nutrition, Livi-Bacci (1991) found no advantage for the better-off group and concluded that nutrition most likely did not have a large contribution. Second, there is some evidence that suggests that during the eighteenth and nineteenth century, there was no relation between long-term trends of real wages (i.e., living standards) and mortality (Wrigley & Schofield, 1981). The focus for a dominant explanation for the mortality decline is then shifted toward the balance between disease and population, in which infectious diseases changed in virulence and the frequency became less lethal (see also Fridlizius, 1984; Perrenoud, 1984; Schofield, 1984). For Sweden, such an explanation found support in several studies. Fridlizius (1984) observed that the mortality development during the late eighteenth and early nineteenth century did not coincide with that of an increase in real wages or the introduction of public health and medical measures, and Fridlizius concluded that the mortality decline was driven by a change in infectious diseases becoming less

virulent. Similar conclusions were drawn when comparing Sweden with the cases of Norway and France (Perrenoud, 1984) as well as England and France (Schofield, 1984).

McKeown's findings and the role of nutrition in mortality decline have been further questioned when proposing public health interventions and preventive health measures as the leading force (Szreter, 1988). A perhaps more prominent argument in favor of public health interventions has been discussed by Preston (1975, 1996), who was able to link the effect of public health measures on mortality decline to the germ theory of disease (see also Preston & Haines, 1991). According to Preston, the germ theory of disease not only stimulated the discovery and production of drugs and vaccines but also prompted other innovations, such as improved antiseptic practices and actions for cleaner food and water, better personal sanitation, and improved infant feeding (Preston, 1975; p. 244). Preston did not disregard the role of nutrition, but in evaluating McKeown's work, he argued that his claims were based on a period (second half of the nineteenth century) when the life expectancy increased only modestly, by approximately six to seven years, leaving the 24 to 25 year gain that occurred in the twentieth century unaccounted for (Preston, 1975). While during the 1850s, John Snow was the first to demonstrate that the diffusion of cholera could be stopped by means of clean water supplies, significant widespread public health interventions did not take place until the end of the nineteenth century, when the germ theory of disease became fully accepted (Cutler et al., 2006). It is estimated that providing uncontaminated water accounted for half of the mortality reduction in the United Stated between 1900 and the 1930s (Cutler & Miller, 2005) and that public health measures, taken together, accounted for 75 to 90% of the growth in life expectancy in the following three decades for the world as a whole (i.e., in both more and less developed countries) (Preston, 1975; for Sweden see Edvinsson, 1995; Edvinsson, 1993; Helgertz & Önnerfors, 2019).

Moving further away from living standards and economic growth as explanations for the increase in life expectancy, Easterlin (1999; 2004) focused on the advances in knowledge about risk factors and on improvements in medicine and public health infrastructures. Interestingly, he highlights the following: first from the mid-nineteenth century, the main factor was the prevention of disease transmission with sanitation and education of the public; then, from the late nineteenth century, new vaccines prevented the spread of certain diseases; the last breakthrough came in the 1930s, with antibiotics and other drugs to cure infectious diseases (Easterlin, 1999; p. 270). Such argumentation highlights a shift from public health interventions to medical treatments. "Antibiotics, developed in the 1930s and 1940s, were the first of the new wave of medical therapies. Sulfa drugs and penicillin were the wonder drugs of their era" (Cutler et al., 2006; p. 103). With infectious diseases being more under control, the impact of medical treatment in mortality reduction became even more evident in more recent decades in relation to the decline in cardiovascular diseases, owing to drugs that treat hypertension (Easterlin, 2000).

In summary, the mortality decline and its determinants over the past three centuries can be roughly divided into three stages. From 1750 until 1850, nutrition and economic growth debatably had a major role in mortality reduction, with a contribution of initial public health measures. Additionally, and of particular interest for the Swedish case in which nutrition and economic growth appears to have had a limited role during this period (Bengtsson & Dribe, 2005), a downswing in long epidemic cycles exogenous to the economy could have played a role (Fridlizius, 1984; Wrigley & Schofield, 1981). However, before 1850, there was only a minor decrease in the adult mortality. Public health measures became the leading force during the second half of the nineteenth century, with public interventions in the supply of water, waste management, food regulations, improvements in housing, and personal health practices. In the last stage, starting from the 1930s and moving into contemporary times, medical advancements such as vaccination and antibiotics first and, then, modern intensive personal medical care played a major role (Cutler et al., 2006).

Socioeconomic status and its dimensions

SES is a widely used concept in health research studies and other research fields that are interested in accounting for social and economic factors, and even though it can have an intuitively straightforward meaning, when considered in detail, it presents a high level of complexity (Galobardes et al., 2006). There is not a unique definition of SES. Some researchers maintain that it is a construct that indicates one's access to collectively desired resources (Oakes & Kaufman, 2017; Oakes & Rossi, 2003), leading to a ranking of individuals based on the quantity of socially valued goods that they possess (Wohlfarth, 1997). Some scholars included prestige-related characteristics in their definition, referring to the relative position in a social hierarchy and therefore preferring the term socioeconomic position (SEP) (Krieger et al., 1997). Eventually, even though SES can be defined by focusing on different nuances (examples of other definitions, Hauser & Warren, 1997; Nock & Rossi, 1979), the commonalities rely on it capturing the variabilities in accessing different material and immaterial desirable resources.

One possible source for the inconsistencies in pinning down a precise definition of SES could be linked to the different indicators that can and have been used to measure it in empirical studies. There is not a single best measure of SES, and there is agreement that different indicators, although often related to one another, gauge different aspects of SES (Braveman et al., 2005; Galobardes et al., 2006). It is therefore important to understand what the different dimensions of SES are and what they tell us.

A first alternative to measuring SES is to use different specifications of social class. Historically, the concept of social class has its roots in the work of Karl Marx, who related an individual's standing in society to the means of production (for example,

factories and land), contraposing those who owned them (such as capitalists) with exploited workers, eventually creating two opposing social groups. In terms of operationalizing such concepts in a class scheme, Wright's work has been considered to be a prominent example, creating a measure of social class based on ownership of capital assets (employer or employee), control of organizational assets (having a managerial position and decision making power), and possession of skills or credential assets (Wright, 1985; see also Krieger et al., 1997; Galobardes et al., 2006a).

Max Weber proposed an alternative view on social stratification with respect to Marx. In Weber's argument, the notion of class is related to "life chances". In other words, what members of a social class have in common is a "*shared typical probability of procuring goods, gaining a position in life, and finding inner satisfaction*" (Weber, 1978, p. 302). While ownership of the means of production and control over goods still plays a role, Weber considers other factors that contribute to social stratification, such as skills and education (Weber, 1978; see also Breen, 2001; Crompton, 2008). Moreover, a further fundamental distinction between the ideas of Marx and Weber is that Weber shifts the focus from class relations based on exploitation and domination within production relations to class relations determined within the market (Crompton, 2008). In other words, society is stratified along several dimensions and, depending on the resources and assets that individuals bring to the market, they will belong to a certain group; people in the same group are characterized by a common market position, which eventually determines their life chances.

Goldthorpe and colleagues (1992; 1980) developed a class scheme that has commonly considered to be close to Weber's work[1] because it was based on the concepts of "market situation" and "work situation", to categorize occupations into different classes. The former refers to employment conditions, economic security, and chances for economic advancement, and the latter points to the level of authority and control of production processes (Goldthorpe et al., 1980). In a later revision, the set of principles that underlie the class scheme has been described in terms of "employment relations" (Erikson & Goldthorpe, 1992). Eventually, the scheme divides occupations into eleven categories. While the grouping considers job characteristics such as independence of work and authority, it does not result in a hierarchical ordering.

As in the case of the Golthorpe scheme, the social class is often constructed as an occupation-based measure, thus indicating what could be called "occupational class". One example is the Registrar General's Social Classes, which groups people

[1] Interestingly the authors do not explicitly categorize his class scheme as Weberian stating that: "*our own approach has often been referred to and discussed as 'Weberian', but we would not regard this as particularly informative or otherwise helpful: to repeat, it is consequences, not antecedents, that matter*" (Erikson & Goldthorpe, 1992, p. 37).

into six categories based on a ranking of occupations according to skills (professional, intermediate, skilled nonmanual, skilled manual, partly skilled, unskilled) (Stevenson, 1928; Szreter, 1984) or the occupational classification initially used in censuses in the United States (Edwards, 1911). In addition to these examples, other social class schemes are available (for reviews, see Bukodi et al., 2011; Liberatos et al., 1988) together with more country-specific classifications developed by national statistical offices (for Sweden, see Bihagen, 2007).

While one's social class in adulthood does reflect aspects that are related to education and income, it also captures other occupation-related factors, including exposure to toxic substances, physical working conditions and work-related stress, as well as the social network that can potentially be accessed through one's job (Galobardes et al., 2006, 2007). Additionally, with respect to other SES dimensions, social class is a strong predictor of lifestyle and behavioral characteristics (Cutler et al., 2012). For example, for smoking, in Northern Europe, education showed the largest inequalities in young adulthood (25-39 years old), while social class was the strongest indicator for the older group (40-60 years old); the effect of household income was small and nonsignificant (Schaap et al., 2008).

Ideally, it would be relevant to measure the social class on different levels of aggregation, namely, individual, household, and community. The individual class is more closely related to occupational health, while the household class reflects the living standards, and the neighborhood (community) class informs on environmental exposure (such as pollution) or crime (Krieger & Fee, 1994).

A widely used indicator of SES is education. It can be measured as the educational level (e.g., primary, secondary, tertiary) and a continuous variable that considers the years of education. Using this dimension of SES presents several advantages, among which it is possible to find ease of measurement, the inclusion of individuals outside the labor force, and stability over the adult life span (Krieger et al., 1997); further, educational information can be easier to collect than other indicators, such as income (Galobardes et al., 2006).

Compared to other dimensions of SES, education is well suited to capture an individual's knowledge-related assets (Lynch & Kaplan, 2000). Furthermore, it is also associated with cognitive functioning and ability to communicate, which positions higher educated individuals in an advantaged position in regard to understanding health educational messages as well as communicating with health services (Galobardes et al., 2006). Additionally, education reflects a transition from childhood to adulthood SES, which is from one's parents' SES to one's own SES; this circumstance means that it could reveal parental material and intellectual resources and choices (Lynch & Kaplan, 2000).

In addition to the social class and education, SES can be measured with financial resources. One of the most common ways to look at financial resources is income. Income can have multiple components that reflect the different sources from which

it is generated and can include wage earning, capital income such as dividends or interest, different types of allowances (e.g., parental benefits, child support, sick leave subsidy) and pensions.

Income represents the SES measures that most directly reflect access to a wide range of material resources (e.g., food and housing). Income is also a determining factor in accessing services directly or indirectly that are related to health. For example, depending on the context, income can be a determining factor in accessing health care. At the same time, higher income levels allow access to leisure activities that can be beneficial for health outcomes (Galobardes et al., 2006).

Other indicators of financial resources that can be found in the literature are measures of poverty and wealth. While income focuses on the entire distribution, poverty and wealth focus more on either end of it. Measuring financial resources with wealth allows us to account for a wider range of assets on top of income, such as the value of housing or other physical possessions (e.g., cars) and certain investments and other forms of savings. Wealth, then, points to economic security and the ability to address emergencies and economic shock (Krieger et al., 1997), with different wealth measures being associated with health and mortality in adulthood and old age (Filakti & Fox, 1995; Laaksonen et al., 2009; Smith & Kington, 1997).

Financial resources, education, and social class are the most widely used indicators of SES in empirical studies. However, in some instances, other measures are also considered. Cutler et al. (2012), for example, include race and ethnicity as SES dimensions with the idea that it is one possible source of stratification in many societies. Nonetheless, even though there is often a strong correlation between SES and race, other authors tend to leave the two separate, arguing that an individual should be able to change their SES without changing their ethnic characteristics (Oakes & Kaufman, 2017).

It is important to point out that the overlap between the different dimensions of SES is far from perfect. Studies of intergeneration transmission of advantage have shown that parental social class and income represent different advantages and are independently associated with child earnings (Mood, 2017). Moreover, while there is a positive association between social and income mobility, it is rather weak, and social mobility only accounts for less than half of the intergenerational income correlations (Breen et al., 2016). As measures of inequality, they capture different social processes that can have different developments over time and across countries (Breen et al., 2016; Erikson & Goldthorpe, 2010). These findings reconcile with the more theoretical view that class and income are different aspects of a person's position in society and therefore should be treated as complementary (Bjorklund & Jantti, 2000, p. 22).

Mechanisms of mortality inequalities

The focus of this thesis is whether different social groups in a population gained in life expectancy more than others. If through time one's social status influenced access to the determinants of mortality decline, whether it was nutrition, a house with clean water and not overcrowded, or medical care later on, then social differences would emerge with gains in longevity that would differ based on social standing. It is therefore essential to examine the determinants of mortality within certain social groups. Given that this thesis takes a long-term perspective and analyzes a long time period, the goal is not only to identify the potential determinants of mortality inequalities but also to understand if and how these have changed through time. Among the factors that have been studied in relation to mortality inequalities, the most common are socioeconomic status, race, and geography (e.g., urban/rural). Here, I will mainly focus on socioeconomic status and review what are the possible mechanisms that are related to mortality.

Given that socioeconomic status has different dimensions as discussed in the previous section, there are multiple pathways that could lead to different health and mortality outcomes (see Table 1).

Table 1: Socioeconomic status dimensions and possible mechanisms that link socioeconomic status to health and mortality

SES dimensions	• Social class
	• Education
	• Financial resources
	  o Income
	  o Wealth

Mechanisms	• Material resources
	  o Nutrition
	  o Housing
	  ▪ Neighborhood
	• Health care
	  o Access to
	  o Quality of
	• Environmental factors
	  o Water sanitation
	  o Pollution
	• Health-related behaviors
	  o Preventive measures
	  o Lifestyle
	• Psychosocial factors
	• Early life factors
	• Reversed causality

Material resources and environmental factors

Higher SES could be linked with more favorable health outcomes because of access to material resources such as nutrition and housing. The possible mechanism related to nutrition is likely to have changed over time; in the past, it was more related to having access to an adequate quantity of food, but in recent times, the focus has shifted to differences in the types of food intake (De Irala-Estévez et al., 2000; James et al., 1997; Smith & Brunner, 1997). While dietary patterns according to SES will be discussed in the next section, SES differences in nutrition in earlier historical periods have been evaluated by looking at height. For Sweden, for example, Öberg (2014b) showed that between the early nineteenth century and mid-twentieth century, fathers with a nonmanual occupation or who were landholders had sons who were taller on average, which suggests an unequal access to food by SES (see also Åkerman et al., 1988 and Öberg, 2016).

Access to better housing could have different aspects besides the mere size and quality of the dwelling, including living in a safer neighborhood, with less pollution, and especially considering the water sanitation of earlier periods. Several studies that looked at the nineteenth and early twentieth century have shown, even with differences in magnitude, the positive impact on reducing mortality of gaining access to clean water and sewerage systems (see, for example, Cutler & Miller, 2005; Harris & Helgertz, 2019). In Swedish cities, for example, Helgertz and Önnerfors (2019) reported that the introduction of water and sewerage systems had complementary contributions in reducing all-cause mortality by 5% and waterborne disease mortality by 9% between 1875 and 1930. If more disadvantaged SES groups were less likely to have household connections to water supplies, the implementation of water systems might have contributed to SES inequalities in mortality. While this type of issue is challenging to study empirically, there is some evidence that suggests that depending on the context, higher SES groups might have had earlier access (Beach et al., 2019; Brown, 1988; Troesken, 2002). For Sweden, a recent study about Stockholm at the turn of the twentieth century suggests that even though higher SES households appeared to have gained earlier access to clean water, SES differences were small, and the delay in reaching more disadvantaged groups was short (Önnefors, 2019). For the more recent period, individual lower SES has been associated with more neighborhood indicators, such as air pollution levels (for a review see Hajat et al., 2015) and other environmental exposures (Adler & Newman, 2002). Furthermore, people in lower SES groups are more likely to live in poorer quality housing, experiencing residential overcrowding and noise, which lead to worse health outcomes (Evans & Saegert, 2000). Eventually, an inverse association has been found between different dimensions of SES and numerous environmental risk factors, including exposure to hazardous wastes and other toxins, outdoor and indoor air and water pollutants, inadequate educational facilities, poor working conditions, and neighborhood quality (for a comprehensive review, see Evans & Kantrowitz, 2002).

Health care

One of the most studied explanations that links socioeconomic status to health and mortality – especially in settings in which there is a lack of universal coverage, such as in the United States – could be that people with a higher income have easier access to better health care (Adler & Stewart, 2010). Indeed, in the United States, even after adjusting for medical needs, medical expenditure increases with income, with inequalities being increasingly larger with age from children to working age adults and seniors (Chen & Escarce, 2004). Nevertheless, inequality in access to health care is not a phenomenon that is limited to the US. Van Doorslaer and Masseria (2004) studied horizontal equity, in other words, medical care utilization among people with similar needs (*"that those in equal need ought to be treated equally"* (van Doorslaer & Masseria, 2004; p. 8)) in the OECD countries. Eventually, they found that total physician utilization is more needed among the poorer strata of the population, but when health care needs were accounted for (i.e., comparing people with similar needs from different income groups), rich people were more likely to visit a physician (van Doorslaer & Masseria, 2004). Perhaps as expected, such inequalities were the largest in the US; what might be surprising, however, is that Finland and Sweden, which provide universal health care, were also among the five countries with the highest inequalities. Interestingly, when the authors broke down the total physicians visits into primary (general practitioners) and secondary (specialists), the income differences were especially large for the latter, which indicates that rich people are significantly more likely to visit a medical specialist (van Doorslaer & Masseria, 2004). A Finnish study reported a significant income gradient in mortality that is amenable to both primary and secondary health care: between 1992 and 2003, amenable adult mortality for men in the highest income quintile decreased by 50%, while in the lowest, it declined by only 10%, and subsequently, the income inequalities increased (McCallum et al., 2013). The differences are present not only when using income but also when wealth and education are considered (Allin et al., 2009; Tedesco et al., 2001).

What is puzzling about the health care access issue is that as mentioned above, differences in health and mortality by socioeconomic status are found also in countries in which there is a universal healthcare system that, in principle, does not differentiate the availability and quality of treatments based on income (van Doorslaer et al., 2000). Although eliminating financial barriers in access to health care is considered to be central to achieving a higher level of equity in outcomes across social groups (Andrulis, 1998; Veugelers & Yip, 2003), it is likely not sufficient to completely eradicate the health gradient in contemporary societies (Adler & Stewart, 2010; Lu et al., 2004). In fact, according to some estimates, among the contributing factors to the ten leading causes of premature mortality in the US (health care, biological determinants, environmental exposure, and lifestyle), the adequacy of health care accounts for the smallest share of 10% (with others

contribute, respectively, 20%, 20%, and 50%) (Adler et al., 1993; Adler & Newman, 2002; Lee & Paxman, 1997).

Health-related behaviors

An alternative pathway that explains socioeconomic differences in health and mortality stems from individuals' health-related behaviors. On the one hand, as hinted above, SES could be related to different patterns of health-seeking behaviors. Studies conducted in Sweden found that lower social group individuals were more likely to refrain from visiting a physician for financial reasons (Elofsson et al., 1998; Westin et al., 2004; Westin & Westerling, 2006) but also for motives related to confidence – they would not visit because they were not confident that a visit would help or they had previous bad experiences (Westin et al., 2004). Burström (2002) pointed out that these differences have been increasing. One of the consequences of this pattern among more disadvantaged groups is delayed detection and care of medical problems, which could result in more severe disease outcomes or even earlier mortality (Eaker et al., 2009; Gerdtham & Sundberg, 1998). On the other hand, health-related behaviors are related to one's lifestyle, such as smoking, alcohol consumption, diet, and physical exercise. Lower socioeconomic status is linked to a higher prevalence of smoking, higher alcohol consumption, more drug use, less physical activity, and higher rates of obesity (Adler & Stewart, 2010; Case & Deaton, 2020; Cavelaars et al., 2000; Elo, 2009; Marmot, 2005). Recently, Case and Deaton have shed further light on the issue of so-called "deaths of despair", showing how, in recent years, increases in drug overdoses, suicides, and alcohol-related liver mortality, especially among the lower educated, have been driving an overall increase in all-cause mortality for white Americans (Case & Deaton, 2015, 2017, 2020).

Lifestyle plays a substantial role in the association between socioeconomic status and mortality (Balia & Jones, 2008; Gregoraci et al., 2017). Interestingly, the association between lifestyle (measured with a comprehensive indicator that accounts for smoking, alcohol, physical activity, diet, sleeping, and television watching) and mortality is increasingly stronger as the degree of deprivation at both the aggregate (area) and individual level increases (Foster et al., 2018). It has been shown that smoking largely explains the difference in mortality among socioeconomic groups (Hiscock et al., 2012; Siahpush et al., 2006). According to some estimates, smoking could explain up to half of the differences in mortality among social strata (Jha et al., 2006; Marmot, 2006). In the United States, one study reported that the combination of smoking, alcohol consumption, and physical inactivity accounts for 68% of the association between socioeconomic status and all-cause mortality (Nandi et al., 2014).

Differences in physical activity across socioeconomic groups are a less clear phenomenon. Although some studies found that higher SES is linked to more physical exercise and argued that it could be one way in which SES differences in

health are created (Jenum et al., 2008; Trost et al., 2002), recent reviews have highlighted that the results are mixed (Beenackers et al., 2012; Gidlow et al., 2006; Stalsberg & Pedersen, 2010). More specifically, it could depend on the type of physical activity that is considered (Stalsberg & Pedersen, 2018). While occupational physical activity is higher in lower social strata and no differences are found for active transport physical activity, higher socioeconomic groups consistently have higher levels of physical exercise in leisure time (Beenackers et al., 2012; Gidlow et al., 2006; Stalsberg & Pedersen, 2010; Stalsberg & Pedersen, 2018). Moreover, among the socioeconomic dimensions, education is the measure that produces the most stable gradient that is robust to possible confounding of other characteristics, such as ethnicity and environment (Gidlow et al., 2006).

There is a generous amount of evidence that alcohol-related mortality is significantly more common among people in lower social groups (see, for example, Blomgren et al., 2004; Probst et al., 2014). What is interesting in considering the association between socioeconomic status, alcohol consumption, and health outcomes is that it does not appear to be due to simple differences in the amount of alcohol that is consumed. For example, a comprehensive review found that individuals in higher social strata consume similar, or in some instances, higher amounts than lower social groups, but the negative consequences of alcohol consumption are disproportionately larger among the latter (Collins, 2016). When evaluating the different aspects of alcohol consumption, the findings suggest that higher social classes could consume alcohol more frequently (i.e., have more drinking occasions), but in lower statuses, especially the less educated, consumption was more frequently binge drinking (Beard et al., 2019). Nevertheless, an investigation from Scotland showed that even after accounting for drinking patterns, smoking, and BMI, given a certain level of alcohol consumed, a lower socioeconomic status was associated with substantially higher levels of harm (Katikireddi et al., 2017).

Over the past couple of decades, there has been increasing attention on so-called "obesity epidemics", especially in the US but also in other parts of the world, with an estimated 1.9 billion adults being overweight and 650 million being obese (WHO, 2020). There is an abundance of evidence that obesity disproportionally affects lower socioeconomic groups (Han et al., 2015; Wang & Beydoun, 2007). Not only individual socioeconomic characteristics but also social-environmental factors play an important role (Zhang & Wang, 2004). Interestingly, the negative relation between SES and body weight that is found in developed countries appears to reverse into a positive association when moving to developing regions (McLaren, 2007; see also Sobal & Stunkard, 1989). One of the reasons for the higher prevalence of obesity in the lower social strata might be the consumption of low quality food due to economic reasons (Akil & Ahmad, 2011). In fact, evidence from several countries shows that individuals in higher social classes tend to eat healthier food, with a higher consumption of fruits and vegetables and lower quantity of fats

(for a review, see Power, 2005) This type of food is in fact more expensive than low quality and less healthy food (Drewnowski & Darmon, 2005; Drewnowski & Specter, 2004). Nevertheless, economic resources are only one part of the story. Using other dimensions of SES, such as education and occupation, could offer further insights into the association between SES and obesity. For example, for women in developed countries, education and occupation as well as area level indicators such as living in an affluent neighborhood showed the strongest negative association with body weight (McLaren, 2007). A strong association with the socioeconomic status is also shown when considering type-2 diabetes (Connolly et al., 2000; Everson et al., 2002; Robbins et al., 2005). In fact, for type-2 diabetes, the education, income, and occupation showed similar relative risks, which appears to hold in both developed and developing countries, even though less evidence is available for the latter (for a review see Agardh et al., 2011). Another interesting aspect about diabetes is the observation that the prevalence is rising. For example, in Scotland, there has been a 40% increase during the 2010s in the prevalence of diabetes, with the aging of the population most likely being one of the driving forces (Colhoun & McKnight, 2020). Strikingly, the gap between more and less affluent is also widening, with the prevalence of diabetes being 80% higher in the most deprived groups of the population compared to the most affluent (Colhoun & McKnight, 2020).

A recent meta-analysis analyzed the independent effects of lifestyle and socioeconomic status on mortality by looking at the set of risk factors highlighted by the World Health Organization (2013) as the 25 x 25 risk factors (high alcohol intake, physical inactivity, current smoking, hypertension, diabetes, and obesity) together with socioeconomic status. The largest share of years-of-life-lost was 4.8 years, and it was due to current smoking (Stringhini et al., 2017). The years-of-life-lost because of smoking were followed by diabetes with 3.9 years, and by physical inactivity with 2.4 years (Stringhini et al., 2017). Low socioeconomic status itself was related to a decrease in life expectancy of 2.1 years (Stringhini et al., 2017).

Although these studies present compelling evidence, behavioral differences and the other factors mentioned above do not explain everything. The socioeconomic gradient in health is still present even after controlling for lifestyle factors (Marmot, 2005).

Psychosocial factors

Increasing attention has been given to the role of psychosocial factors, namely, social and psychological circumstances related to a low level of control over the work place and home life, which can have a substantial impact on health (Wilkinson & Marmot, 2003). In considering the psychosocial factors, the focus moves from material resources to social capital and other concepts related to the social environment, such as social isolation affecting the development of constant anxiety, insecurity, low self-esteem, and satisfaction. While the importance of material

factors is still acknowledged, social stress and an individual's relative position in society are the main drivers of health (Marmot, 2005; Morin, 2006; Siegrist & Marmot, 2004; Singh-Manoux, 2003).

Among the most relevant work with particular attention to psychosocial factors has been the Whitehall II study, in which the employment grade level was inversely associated with several health outcomes (Marmot et al., 1991). In a later investigation, it was further found that the psychosocial work environment accounts for the largest part of the social gradient in the incidence of cardiovascular diseases, with other risk factors in adulthood and in early life having a smaller contribution (Marmot et al., 1997; for a review see also Everson-Rose & Lewis, 2005). At the basis of the psychosocial argument, there is the fact that health and mortality differences are still evident when excluding the richest and the poorest in society. The Whitehall study, for example, focused on white collar workers for which the health gradient could not be solely due to differences in material conditions, which led to the conclusion about the importance of psychosocial factors and that the relative position in society could be as important as absolute differences in material resources (Marmot & Wilkinson, 2005; Marmot & Wilkinson, 2001). Several studies have confirmed the importance of psychosocial factors on health; these studies looked at different indicators, such as control over the workplace, social support and social integration (for a review, see Lundberg, 2008).

Early life factors

Conditions in early life are another possible mechanism for the relation between SES and adult health and mortality. While a large part of the literature on health inequalities by SES focuses only on individuals' characteristics in adulthood and older ages, it is well-established that conditions early on have long-lasting impacts on health and other outcomes (Barker, 1998; Bengtsson & Lindstrom, 2000; Bengtsson & Broström, 2009; Case & Paxson, 2009; Elo & Preston, 1992; Quaranta, 2014). Since the development of organs and cells is most rapid during the fetal stage and in infancy, these are critical periods in which adverse exposures have lifelong and irreversible impacts (Kuh & Shlomo, 2004)

More specifically, being exposed to low nutrition and a high disease load earlier in life could increase the likelihood of chronic disease in adulthood as well as lead to impaired cognitive ability, which will compromise an individual's ability to work. If this concern is the case, then the exposure in early life could explain both health and SES in adulthood. Alternatively, another early life factor of interest is the childhood socioeconomic circumstances. In such a case, a child from a wealthier family could benefit from, for example, higher investments in education, which will in turn affect adulthood health and SES (Case et al., 2005; Currie, 2009; Elo, 2009).

Reversed causality

One of the main concerns in studying SES inequalities in health and mortality is causality. At the same time, the focus of this thesis is not on assessing the direction of causality, but rather to present the long-term development of the SES-mortality association while recognizing that causal effects could work in both directions. It is worthwhile to briefly describe how this possible mechanism works.

The idea is that while SES might have a causal impact on health, the opposite could also be true, with a causal effect from health to economic status (e.g., Cutler et al., 2012; Deaton, 2003; Montez & Friedman, 2015; Smith, 1999, 2004). This effect would be the case if, for example, a healthier child has better school results or if an increase of investments in education follows the expectations of a longer and healthier life (Cutler et al., 2012). Alternatively, it could also be possible that a healthier person can work more and have a better job, which could also lead to a higher income (Chandra & Vogl, 2010).

In addition to endogeneity, the association between education and health might also be confounded by unobservable covariates that affect both dependent and independent variables, which sometimes are not available or possible to measure. Genetic characteristics, parental background, or time preferences are examples of confounders (Lleras-Muney, 2005). Fuchs, (1980) argued, for example, that discount rates (which indicate how much a future reward is valued) could have an impact on the relationship because impatient people invest much less in both education and health with respect to patient individuals. To overcome such drawbacks, authors have been relying on quasi-experimental methods, such as instrumental variables and regression discontinuity, which provide a setting that is closer to a randomized trial and therefore provides stronger causal inference power.

Lleras-Muney (2005) investigated whether education has a causal impact on health with an instrumental variable setting, using the 1915 and 1939 compulsory education laws as instruments for education. Their paper shows that education has a large causal effect on mortality: one additional year of education decreases the probability of dying in the next ten years by 3.6 percentage points. Arendt, (2005) studied the case of Denmark with a similar framework, using 1958 and 1975 Danish school reforms as instruments. In contrast to the paper mentioned earlier, Arendt does not find significant results. However, Arendt (2008) improves on the previous work using quality register data (a larger dataset) and more efficient estimation methods (still using school reforms as an instrument) and finds support for the causal relation between education and health only for women. A recent study based on information for Swedish twins found that the life expectancy at age 60 was three years longer among higher educated compared to lower educated individuals (Lundborg et al., 2016). Adams (2002), Arkes (2003), and Spasojević (2010) are other examples of authors who addressed the causal problem and found an effect,

whereas Clark and Royer (2013) is an example of a study in which a significant causal effect of education on health is not found.

Assessing the causality between income and health is difficult, and the direction of the effect is far from clear and sensible to age (Cutler et al., 2012). However, with an IV setting, Ettner (1996) finds that physical and mental health improves with increasing incomes. The author argues for a causal effect and that the results are highly statistically significant and robust to the choice of the identifying assumption. However, among different studies, the findings are mixed. Some studies have not found any effects on health and mortality from random wealth shocks following lottery wins (Cesarini et al., 2016). Meer et al. (2003), for example, found that there is a statistically significant effect of wealth on health, but it is very small in magnitude. (For different empirical designs, see Kawachi et al., 2010 and Lindahl, 2005; see also O'Donnell et al., 2015 for a review.)

Summary

Taken together, the literature about possible mechanisms between socioeconomic status and health and mortality does not present one single culprit, but instead, it points toward a complex framework of factors that are related to the position within society of an individual. One key aspect that can help in deepening our understanding in this area of research is to investigate and understand how SES has changed its influence on mortality over a long period of time. In studying the social differences in mortality over a long period of time, there are several factors at play that must be considered together. Certainly, it is central to evaluate simultaneously the changes that occur in society with the changes in the disease environment.

Long-term development of SES differences in mortality

Within the most recent literature, one of the most prominent frameworks about socioeconomic differences in mortality is the Link and Phelan (1995) Fundamental Cause Theory (FCT). The basic idea of the theory is that social causes (i.e., money, knowledge, power, prestige, social networks) are linked to a set of resources that allows the individual to avoid or decrease exposure to risks or to minimize the consequences of such exposures (Link & Phelan, 1995; p.87). From a policy perspective, the most important contribution related to the concept of SES as a fundamental cause is that it invites us to contextualize risk factors or, in other words, to consider what puts people "at risk of risks" (Link & Phelan, 1995; p.85). For example, while poor diet and lack of exercise are associated with an increased risk of certain diseases, policies aimed at changing such habits might not be as effective if they do not account for the fact that the lifestyle is strictly embedded with social factors that put people at risk of bad habits in the first place. A characteristic of the FCT is the distinction between individual and contextual factors (Phelan et al., 2010). On the one hand, individual factors refer to what affects health through what

people do, know, have access to, can afford, and receive social support for; on the other hand, contextual factors reflect the environment in which people live, such as a neighborhood with more or less crime, pollution, and parks (Phelan et al., 2010; p.S30).

When the FCT is considered in the time dimension, the results suggest a persistent association between SES and health regardless of the changes in the underlying mechanisms, because a higher socioeconomic status will facilitate access to such mechanisms. In sociology, the fundamental cause theory has been explained as based on a "metamechanism"; the idea is that while several discussions of SES differences in mortality are based on specific factors (e.g., material resources or lifestyle), the FCT embodies a variety of mechanisms that ensure its theoretical relevance through space and time (Freese & Lutfey, 2011; Lutfey & Freese, 2005). A logical consequence of the FCT is that if the theory holds, we should see larger differences in mortality by socioeconomic status in preventable causes of death with respect to nonpreventable. Hence, the gap should be larger in mortality that is under greater human control and that can be avoided by having access to the advantages of higher SES. Empirical findings based on data from the more recent decades do support this theory, showing that higher SES is protective for a wide array of preventable diseases associated with higher education or more resources (Mackenbach et al., 2015; Masters et al., 2015; Phelan et al., 2004, 2010)

When looking farther back in time, however, the constant relation between SES and mortality could be questioned. Antonovsky (1967), for example, argued that mortality differentials had been changing throughout history and suggested that there were different levels of inequalities for three different historical periods. He maintains that before the seventeenth centuries, there were no inequalities because of the dominance of highly virulent and communicable diseases. In the two centuries between 1650 and 1850, instead the gap between higher and lower SES widened due to increasing economic inequality, less virulent diseases, and mortality being more related to nutrition. Last, in the third phase, namely, 1850-1970, the gap narrowed owing to decreasing economic inequality and broader and more equal access to health care. On the basis of Antonovsky's study, there is the observation that mortality differences among social groups are influenced by the overall mortality rate. When the mortality rates are high, inequalities are small because of the limited human agency in avoiding death; narrow inequalities should be in place also when mortality rates are very low because of the achievements in mortality-reducing measures that have spread to the entire population. Social differences in mortality will arise when death is preventable only with a certain level of knowledge or with access to a certain technique (Antonovsky, 1967; p. 68). In this last part, there is a similarity with the FCT. Smith's (1983) view is also in disagreement with a persistent lower mortality in higher SES groups, by arguing, in a similar way to Antonovsky, that in the past, lower and upper classes were equally exposed to communicable diseases.

A key factor to consider is the disease environment that is present at the specific point in time that is under study. In fact, that is what Clouston et al. (2016) did in a recent update of the FCT in which they account for aspects of the demographic and epidemiological transition. The idea is that even if the overall mortality is declining, there are new diseases that are emerging and dominating the trend and that mortality differentials from all diseases go through the same four phases. In the first phase, diseases cannot be prevented because there is no knowledge of possible treatments. In this point, socioeconomic differences in mortality from the diseases are small and can, sometimes, be reversed. As time goes by, new knowledge on how to prevent or cure diseases emerges and, since higher status groups are usually the first in acquiring this information, social differences start increasing; the mortality of the high-status groups starts to decline, while that of the low-status groups remains high. In the third stage, awareness about how to manage diseases is spread to a larger portion of the population and low status group health starts to improve. At this point, the rate at which mortality declines for lower SES groups is faster than those at higher levels, with a resulting decline in inequalities. Finally, the impact of mortality-reducing innovation reaches the maximum, and no improvement can be made. While sometimes the disease is eliminated throughout the whole population, in other cases, differences between higher and lower SES groups persist due to differences in behavior or access to resources. Eventually, the point that Clouston and colleagues want to make is that the process just described is cyclical and is observed for every disease over time. As a consequence, socioeconomic differences in overall mortality will always be present.

Before this thesis, empirical evidence about the development of social differences in mortality was fairly scarce, and longitudinal studies that cover a long period of time until recent years were even rarer (Bengtsson & Dribe, 2011; Edvinsson & Broström, 2012; Edvinsson & Lindkvist, 2011; Razzell & Spence, 2006; Schenk & van Poppel, 2011). Favorable to this line of research has been the continuous digitalization of historical sources and updates of more and more extensive and comprehensive datasets available to historical demographers. Indeed, more recently, other studies have been produced alongside this book, shedding light on the matter (Bengtsson et al., 2020; Dribe & Eriksson, 2018; Edvinsson & Broström, 2017; Mourits, 2019).

Context

Economic and social developments in Sweden

The last two centuries in Sweden have been characterized by dramatic changes in several aspects of the economy, society, population, health, and their reciprocal influence on one another. To provide a clear picture, it is worthwhile to divide the period into several portions, beginning with the nineteenth century, continuing with the first half of the twentieth century, and then with the period from the 1950s onward.

From the beginning of the nineteenth century to the later years, mortality shifted from a pretransitional level to a continuously decreasing trend, the population more than doubled, and the society shifted from preindustrial to an early industrial setting. Public health developed through the implementation of clean water systems and the first hygienic measures, particularly towards the end of the period. Before the 1860s, Sweden's economy was largely dominated by agriculture, employing more than 60% of the population, with approximately 90% of the people living in rural areas (Schön, 2007). During these decades, agricultural outputs and commercialization improved thanks to new techniques, the introduction of new crops, and a decrease in transportation costs due to investments in infrastructures (Schön, 2007). Overall it was a period of modest but, for the first time, sustained growth which spread from agriculture to other sectors such as manufacturing and transportation (Schön, 2010). The other positive aspect of increased agricultural production is that the output increased faster than the population, and Sweden shifted from being an importer to an exporter (Schön, 2010). In terms of health, there are several major interventions to be highlighted. Surely, the mandatory vaccination against smallpox introduced in 1816 is one part of the story (Sköld, 1996), together with a reduction in mortality related to childbirth with the spread of information in support of breastfeeding and improved hygiene in infant care (Lazuka et al., 2016; Sundin & Willner, 2007). Overall, this phase has been famously summarized in three words by the poet Esaias Tegner *"peace, vaccine, and potatoes"*, with peace referring to the uninterrupted period of peace that began in 1814 resulting in the disappearance of mortality related to wars, particularly for men of reproductive age (Nordstrom, 2013). While the view of the demographic transition identified by Tegner's phrase holds some truth, it has been called into question, as the timing of peace, vaccination and medical progress, and improvements in living standards (potatoes) does not entirely coincide with the initial phase of mortality decline (Bengtsson & Ohlsson, 1994). As mentioned above in the brief review of determinants of mortality decline, in the case of Sweden, it seems that the initial decrease was a result of a diminished virulence of infectious diseases (e.g., smallpox) and, only later in the nineteenth century, improved living conditions and better medical and sanitary systems helped continue the downward trend (Bengtsson & Ohlsson, 1994).

The second part of the nineteenth century marked the onset of Sweden's industrialization with an increasing quantity of exports and industrial investments, as well as a growing infrastructure with railways more and more at the center of attention, attracting substantial import of capital alongside an improvement in the banking system (Schön, 2007). The development of infrastructure and economic growth was in general favored by a financial revolution that took place between the 1850s and the 1870s, leading to increased liquidity and financial services (Ögren, 2009). Of relevance was also the expansion of certain industries, such as the sawmill industry and the pulp industry (Schön, 2010). An important aspect of the expansion of the manufacturing industry was the emergence of a new working class; between 1850 and the end of the nineteenth century people employed in the industrial sectors (e.g., sawmill workers, artisans) more than tripled (Schön, 2010; p. 156). Facilitated by the arrival and expansion of the railway, people started to move towards more urbanized areas (Berger & Enflo, 2017). At the same time, a large emigration mainly to North America took place. The internal migration to cities created some public health problems from overcrowded housing and the spread of air- and waterborne infections to considerable alcohol consumption, facilitated by a lower degree of social control and easier access to cheap drinking in cities compared to the countryside (Sundin & Willner, 2007). However, clean water provision and investments in sewerage contributed to decrease mortality (Helgertz & Önnerfors, 2019), and alcohol consumption regulations were introduced (Sundin & Willner, 2007).

During the first half of the twentieth century, industrialization continued, and growth picked up. A first part of the story is scientific knowledge, engineering skills, and the increasing importance of the electrical motor, leading to increased investments in infrastructure for electrification and the founding of companies such as Ericsson and of the Royal Institute of Technology (Schön, 2007). In the years between 1910 and 1950, Sweden consolidated its growth, which can be associated with three factors. First, the industries were able to exploit a large part of their growth potential by meeting internal and external demand both in war and interwar periods. Second, the increase in exports led to a strengthening of the internal financial market, with lowering interest rates prompting industrial activity, and in parallel the state gained sufficient resources to implement economic and social policies. Last, population growth and a decrease in emigration caused an increase in labor supply that, together with the supply of capital and industrial development mentioned above, enabled the country to meet both domestic and external demand (Schön, 2007). The growing industrial society and urbanization (in the 1930s the share of people working in industries became larger than those employed in agriculture, and at the same time more people were living in urban areas than rural (Sundin & Willner, 2007)) also called for a sociopolitical change of outdated regulations based on an agrarian society, leading to increasing pressure for social welfare reforms (Schön, 2010). One of the most important reforms, the National Pension Insurance Act of 1913, put Sweden on the map as one of the most advanced

countries in terms of social policies (Schön, 2010). A rising concern in welfare reforms was also seen for public health, with an increased attention to hygiene and cleanliness (Sundin & Willner, 2007). During the first part of the twentieth century, regulations regarding alcohol consumption were made stricter with a rationing of t distribution and a monopoly on alcohol trade and imports (Sundin & Willner, 2007). Between the 1920s and the 1940s, the welfare state expanded with economic safety nets for sick and unemployed people and with health care becoming more accessible, and the introduction of sulfa drugs and penicillin alongside new vaccines and antibiotics contributed to population health at a large scale (Sundin & Willner, 2007). In this period of particular importance was also the institutionalization of maternal and child healthcare, which replaced more rudimentary philanthropic types of care, in addition to the establishment of district nurses who helped to provide an all-encompassing healthcare (e.g., dealing with emergencies, advising on hygiene and infant care, controlling school sanitary conditions) in more rural areas (Lazuka, 2017; Sundin & Willner, 2007). Economic and welfare developments went hand-in-hand with marked societal changes in terms of education, women labor force participation and occupational structure. Sweden has a longstanding tradition of compulsory schooling, dating back to the mid-nineteenth century when church parishes were requested to provide primary school services to children (Fredriksson, 1950). However, there were large differences in length and quality of education among regions until 1919 when the national government issued directives that greatly homogenized educational guidelines throughout the country, and between 1930 and 1950 a further school reform was introduced extending the compulsory years of schooling and the annual term length (see Fischer et al., 2016). Labor force participation of women (both married and unmarried) also increased, following an expansion in sectors such as administration, healthcare, and education, increasing demand for female labor (Stanfors, 2014). At the same time, women advanced their educational achievements allowing them to aim at white-collar jobs with higher earning opportunities, eventually leading to increased wages and a reducing wage gap with men (Stanfors, 2007, Chapter 4).

The more recent period spans from after WWII until the first decade of the twenty-first century. The first half of this period was the golden age of Swedish industrialism with extremely high levels of employment and also expansions in energy supply, housing, and transportation, and it was characterized by two main components. One the one hand the full exploitation of earlier innovations (i.e., electrical motor and combustion engine) fueled increased productivity in manufacturing with the expansion of engineering, shipbuilding, and steel and paper companies, which also benefited from an increase in exports. Productivity increased also in agriculture, thanks to mechanization. On the other hand, the solidification of the Swedish welfare state played a complementary role with a widening supply of public services such as education, health care and childcare. At the same time, there was also an expansion in social security and pensions. A significant role in sustaining growth was also played by public investments in infrastructure and

residential projects (Schön, 2007, 2010). In the second half of the period, from 1975 onward, the third industrial revolution took place with a strong development of the service sector. During these years, steel, pulp and paper, shipbuilding and mechanical engineering industries started to face challenges keeping up with new global competition, so while the shipbuilding industry almost disappeared, the others were modernized and digitized. As the 1990s approached with the "electronic revolution", knowledge-intensive industries were taking the lead, such as IT, pharmaceuticals, and biotechnology, as well as service industries. Throughout the second half of the twentieth century, the continued expansion of the public sector in teaching, health care and childcare went hand-in hand-with an increasing participation of women in the labor force (Stanfors & Goldscheider, 2017). The structural change in Swedish economy with the expansion of new trade and industry led to increased wages for women driven by market forces, so that where demand for female labor was high, wages rose (Stanfors, 2007, Chapter 4). Education played a central role, too. The schooling reform introduced after 1930 mentioned above led to increased earning by the 1970s, particularly for women (Fischer et al., 2016). The educational system continued to develop. During the 1960s elementary and intermediate schools were merged into a 9-year compulsory school (Lundborg et al., 2014). The 1990s was another period of fundamental reforms in the school system. With the abolishment of separate courses, primary education became more universal; secondary education was also expanded with 3-year programs preparing students to enter higher education (Stanfors, 2003, Chapter 6). The educational expansion was closely related to the societal and economic structural changes taking place in the country (Ekstedt, 1976; Ohlsson, 1986). Increasing enrollment in higher education has been argued to be one of the main factors that led to economic growth since the late nineteenth century (Ljungberg, 2002; Ljungberg & Nilsson, 2009). In terms of the epidemiological environment, two of the features that characterized this period were the low prevalence of infectious diseases resulting from earlier public health and medical advancements (e.g., sulfa drugs and penicillin) and at the same time the increase in deaths caused by cardiovascular diseases and cancers (especially lung cancer). Alcohol-related deaths also increased, possibly as a result of less strict regulations with the abolition of the rationing system in 1955, the liberalized sale of medium-strong beer, and in 1995 joining the European Union, which led to less restrictive rules for imports from other EU countries. Following this trend, public health attention shifted to addressing individual lifestyles with campaigns against smoking tobacco, obesity and alcohol consumption. During the latter part of this period, mental health became a rising issue, and psychosocial factors gained increasing attention, raising concern for stress related to the workplace, unemployment, control over one's life, and social isolation/social networks (Sundin & Willner, 2007).

The context in Scania

The area considered in the first, second, and fourth studies comprises five parishes and one town in Scania, the southernmost region of Sweden (Figure 5). For the rest of the country, during the period considered in this thesis, this area underwent tremendous economic and social development.

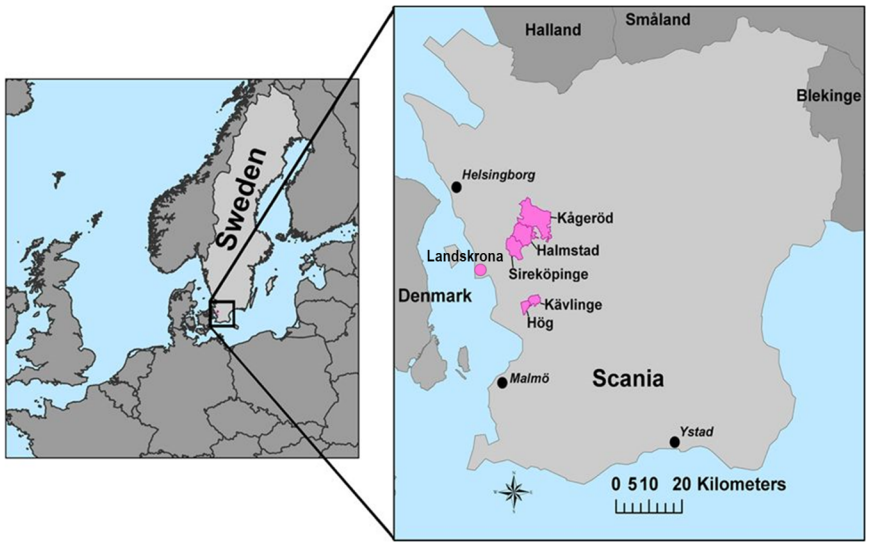


Figure 5: Area in southern Sweden analyzed in the first, second, and fourth paper.
Source: adapted from Hedefalk et al. (2017).

During the nineteenth century, the focus is on the five parishes of Hög, Halmstad, Sireköpinge, Kågeröd, and Kävlinge, with a combined population of just under 4000 inhabitants in 1830. In the first half of the nineteenth century, this area was mostly open farmland with the exception of the wooded northern part of Halmstad (Bengtsson & Dribe, 2014). Agriculture and grain production was more central to the economy of the region than animal husbandry, with important transformation happening during the eighteenth and nineteenth centuries in terms of new crops, reclamation of land, and enclosures (Bengtsson & Dribe, 2010; Quaranta, 2013). The second part of the nineteenth century marked the beginning of the industrialization period, particularly in Kävlinge, which experienced the most substantial change with concomitant industrial and infrastructure expansion. More specifically, important contributions to development were made by the construction of a railway station in 1886 and by the establishment in the 1890s of a leather and shoe factory, a sugar mill, a glove factory, and in a neighboring parish a textile factory (Bengtsson & Dribe, 2011; Billing et al., 1983; Högs by skifteslag, 2000; Niels-Erik et al., 2019). Important for the development of the region during this

period was also the construction of the railway line connecting Malmö to Göteborg in 1890 (Dribe et al., 2015; Niels-Erik et al., 2019).

During the twentieth century, industrialization and population growth in the five parishes continued. A meat industry opened in 1918, and in 1907 the railway reached Hög which, although being the parish that maintained rural character for a longer period, was likely affected by proximity to the more industrially developed Kävlinge (Dribe et al., 2015).

In terms of health and mortality, development over time in the five parishes has been similar to that of the whole country. For instance, using height as an indicator of health, it has been shown that the average heights of conscripted men in the five parishes and in Sweden as a whole were almost identical from the late nineteenth century to the 1960s (Öberg, 2014; p. 17). Similarly, life expectancy at birth showed a similar development over time (Quaranta, 2013; p. 53).

For the twentieth century, the area included in the analyses is extended to also include the port town of Landskrona. In the earlier part of this period the development of Landskrona into an industrial city was already underway (Jönsson, 1993) with infrastructure investment in public transportation, in health care with the construction of a new hospital, in education with the establishment of a municipal high school, and in urban development with ambitious housing construction plans (Dribe & Svensson, 2019). In line with its industrial character, most of the working population was employed in manufacturing and, as of 1910, particularly in the food industry (sugar and tobacco), textiles, and mechanical industry (Dribe & Svensson, 2019). Over time, the share employed in the food and textile industries decreased and left room for a growing machine sector, which had the highest percentage and to the paper/pulp and chemical industries (Dribe & Svensson, 2019).

Data

The empirical analyses presented in the following chapters are based on a multitude of data sources. Studies one, two and four use the Scanian Economic Demographic Database (SEDD - Bengtsson, Dribe, Quaranta, et al., 2020), while study three exploits information from Swedish censuses (Riksarkivet, www.riksarkivet.se) and the Swedish death index (Sveriges Släktforskarförbund, 2019). For the pre-1968 period, the information is based on historical sources such as parish registers and birth/marriage/death certificates that have been digitized and maintained by various institutions. For the period from 1968 onwards, data were taken from several national administrative registers from Statistics Sweden (Statistiska centralbyrån - SCB) and the National Board of Health and Welfare (Socialstyrelsen).

Table 2: period covered and data used in each paper

SEDD version 6 (data for Landskrona available from 1922)															Paper 1
					SEDD version 7.1 (income information is available since 1905)										Paper 2
					SEDD version 7.1 (data for Landskrona available since 1905)										Paper 4
1813	1860	1880	1890	1900	1905	1910	1950	1968	1970	1980	1990	2001	2014	2016	Time
		Census	Census	Census		Census	Manual		Census	Census	Census	Register			Paper 3
	Swedish Death Index														

Historical sources	National administrative registers since 1968

The Scanian Economic Demographic Database

The SEDD is a dataset containing individual-level information for residents living in five parishes and a port-town in the south of Sweden. Subjects are followed since 1813[2], birth or immigration until 2016, death or emigration. It provides a wide array of individual and household information about demographic events such as births, marriages, and deaths and socioeconomic variables such as occupation, income, and land ownership.

The underlying source for the pre-1968 period consists of continuous population registers kept by the clergy (catechetical examination registers *husförhörslängder*), in which households are continuously followed and information for individuals within each household is continuously updated. In addition, birth, marriage, and death certificates have been used to complement the population registers and account for possible under-recording of such events. Furthermore, the population registers have been linked to poll-tax registers (*mantalslängder*) and annual income and taxation registers (*inkomstlängder*) to complement the information on occupation from the population registers and to obtain information on income. The occupational information in the population registers was declared at birth and marriage events, while that from the poll-tax registers and the income registers was updated annually.

For the period from 1968 onward, individuals have been linked to the national administrative registers maintained by Statistics Sweden and the National Board of Health and Welfare through the personal identification number that was introduced in 1947. This linkage permitted extension of the coverage of this period in the dataset in several ways[3]. First, individuals can now be followed regardless of their geographical location. This means that if an individual emigrated from the area covered by the SEDD and went somewhere else within Sweden, this person can be followed. In addition, anyone related to the individuals mentioned so far (i.e.,

[2] The starting point slightly varies among parishes. In the Kågeröd parish subjects are followed since 1813, in the parishes of Halmstad and Sireköpinge since 1821, and in the parishes Hög and Kävklinge since 1829.

[3] This was completed within the project "Economic demography in a multigenerational perspective" which was granted permission from the Regional Ethics Committee in Lund (2010/627).

spouses, parents, grandparents, children, and siblings) are added to the sample as long as they were alive and living in the country. All the individuals added based on these extensions are similarly followed until 2016, emigration, or death.

Censuses and the 1950 mantalslängden

The third study combines several historical and contemporary data sources. First, it considers information from the 1880, 1890, 1900, and 1910 Swedish censuses, which have been digitized by the Swedish National Archives (Riksarkivet, www.riksarkivet.se), which made them available to the Center for Economic Demography (CED) at Lund University, formatted according to IPUMS standards (www.international.ipums.org).

Unlike censuses compiled in other countries (e.g., US or UK) the Swedish ones are not the result of enumerators visiting and counting the population; they are instead a combination of information from the continuous parish registers mentioned (Eriksson, 2015). The only exception is the information for the city of Stockholm, which is based on the Roteman register, which was an administrative register kept by the population and tax registration board (Eriksson, 2015). This difference in the source material was because towards the end of the nineteenth century, Stockholm was expanding rapidly. Therefore, in 1878, the church registers were replaced with the Roteman system, which, as a dedicated population and tax registration board, could better cope with a growing population and increasing migration flows in and out of the city as well as within (Geschwind & Fogelvik, 2000). Because of the different nature of the underlying source material, the data quality from Swedish censuses is better than information from US or British censuses (Eriksson, 2015).

The second database used in the third study is the 1950 poll-tax register (*mantalslängden*). While the structure is almost identical to that of the censuses described above, the information in this case was digitized by Arkiv Digital (www.arkivdigital.se) and made available to CED at Lund University.

These sources include variables for households and individuals within each household (e.g., occupation, civil status, year of birth, residence location) covering the entire country. However, they do not provide all the necessary tools to conduct a study about mortality, as they do not contain information on place and date of death. To this end, it was necessary to link them to the Swedish Death Index (*Sveriges Dödsbok*), which is a dataset including all deaths that occurred in Sweden between 1860 and 2016 provided by The Federation of Swedish Genealogical Societies (Sveriges Släktforskarförbund, 2019). The challenge in doing so was that in the late nineteenth and early twentieth century there were no personal identification numbers, eliminating the possibility of deterministic linkage between the sources. Nevertheless, both sources comprise names and surnames, which allowed for a probabilistic linkage approach. Additionally, due to the relatively high

quality of the raw data, it was possible to obtain a high linkage rate and a low rate of false positives (Eriksson, 2015).

Measuring SES over a long period of time

One of the main challenges involved in looking at socioeconomic differences in a certain outcome over a wide time span is having a consistent and comparable measures for the exposure (i.e., of socioeconomic status). While it is possible when using income to adjust and standardize figures in order to make them homogeneous over time, for social class it is less straightforward. From the early nineteenth century until the 2000s, there has been tremendous development in the economy and in social class structure. Sweden moved from an agrarian to an industrialized society with consequent changes in occupational structure. At the same time, the level of education markedly increased and the move towards mechanization of production allowed an increase in productivity. These trends resulted in a sharp increase in the share of people with white-collar occupations and, at the same time, a fall in the share of workers employed in agriculture. Given these developments, the distinction between different levels of skilled labor may be potentially problematic. The question then is whether social stratification changed over time and potential issues arise in case there were marked shifts in the social hierarchy.

Important for the work presented in this thesis is to establish if and how the relative difference in terms of social standing between, let us say, a professional and an unskilled worker in the 2000s was different from what it was in the 1850s. If there has been a large change in the relative standing of social classes in two different time points, interpreting social inequalities in a certain outcome would raise concerns. That is, it would be uncertain if the emergence or the disappearance of the inequalities was due to the actual presence (or lack of) inequalities or else due to failure of the social class scheme to capture stratification within the society.

The early status continuity literature mainly focuses on occupational prestige. Among the first studies that tried to evaluate changes in occupational prestige is the work of Hodge and colleagues (1964), in which they evaluated occupations in the United States between 1925 and 1963. They presented two interesting conclusions. On the one hand, “the structure of occupational prestige is remarkably stable through time as well as space”, on the other hand, during the latter part of the period under consideration scientific occupations and artisans showed a small increase in prestige, while prestige decreased for cultural professions such as artists, musicians, writers, and journalists (Hodge et al., 1964). The potential issue with their analysis is that it covered only a limited portion of the occupational structure and, particularly for the earlier period, the quality of the data is questionable (Sobek, 1996). Plata (1975) in his analysis, which combined his data with four previous studies published between 1925 and 1974 (i.e., Braun & Bayer, 1973; Counts, 1925; Deeg & Paterson, 1947; Hakel et al., 1968), found that even after accounting for the role of race,

educational level, and sex "The prestige level of occupations have withstood the test of time including WWII and even sociological and educational changes". This study was later replicated by Fossum and Moore (1975), who added a further occupational prestige evaluation and arrived at a similar conclusion of stability over time (for a review see Wegener, 1992).

One of the most influential contributions on this topic comes from Treiman (1976), who studied a much longer time period in different countries (and cultures), including among others fourteenth century Nepal, fifteenth century Florence, and late nineteenth century London, and eventually concluding occupational status hierarchies were highly stable across the different settings. Treiman argued that occupations are recognized with respect to power, privilege and prestige, which are all attributes that have high correlations across borders and societies (Treiman, 1976; p. 289). While other authors have presented similar arguments (Inkeles & Rossi, 1956; Marsh, 1971), Treiman has received some criticism about his use of scant historical data covering only a small portion of occupations and inconsistent prestige measures (Sharlin, 1980; Sobek, 1996). Nevertheless, in another comprehensive study comparing 55 countries, Treiman found again that hierarchies of prestige, power and privilege are more or less constant across societies (Treiman, 1977; p. 223). Other extensive studies showing consistency across space and time of occupational status rankings include (Hauser, 1982; Hershberg et al., 1974).

To a certain extent, the literature presented so far has established a high degree of stability of social standing over time by looking at the prestige of occupations. However, even though some claim that prestige scales are independent of the way they were determined, namely, that there are high correlations both among expert historians and between historical and contemporary rankings (see van Leeuwen & Maas, 2010), some authors have been more skeptical and have shown some doubts about the reliability of using prestige. Sobek (1996; p. 177), for example, raises the question "how surprising is it that a group of late-twentieth-century scholars all exposed to modern census schemes … and reading the same books, have come up with similar rankings of occupations, or that those rankings are consistent with contemporaneous ones?" Following this doubt, an alternative approach has been to combine occupation and income to create a scale. This method is more objective, as income is less subjective and is more measurable (Sobek, 1996). Interestingly, the conclusion is substantially the same; regardless of the remarkable social and economic changes, the relative standings of occupations have remained stable over the last century (Sobek, 1996; p. 189).

Overall, even if some skepticism remains (see Hauser & Warren, 1997), the literature presents a multitude of suggestions that relative social standings have been reasonably constant over time. In a relatively recent contribution, (Hout & DiPrete, 2006) collected results from the rc28 conference and from a literature review, listing an array of sociological empirical generalizations, among which we can find the ranking of occupations in the same order across space and time. Considering also

the more recent work of Treiman (Ganzeboom & Treiman, 1996) and his findings about the stability of prestige across countries and periods, they refer to this pattern of invariance as the "Treiman constant", ranking it as first among the achievements of RC28 and possibly the only universal in sociology (Hout & DiPrete, 2006; p. 3).

Keeping all these considerations in mind, one of the most recently created class schemes is the Historical International Social Class Scheme (HISCLASS) (van Leeuwen & Maas, 2011). This scheme is based on the Historical International Standard Classification of Occupations (HISCO) (van Leeuwen et al., 2002, 2004), namely, a list of occupations which have been standardized to be comparable across different geographical settings and across time periods. HISCLASS then groups occupations into twelve social classes accounting for whether an occupation is manual or nonmanual, the skill level required, the level of supervision and the economic sector (van Leeuwen & Maas, 2010). HISCLASS also considers the status and relational aspects of HISCO classification. Status captures occupational characteristics such as ownership, artisanal career, level of subordination, tertiary education and pure status. Prestige is considered in assigning HISCLASS categories in the status component (van Leeuwen & Maas, 2011; p.59). Relation instead measures family relationships, temporal relationships such as "former" or "retired", voluntary or honorary relations, house workers, and incapacitation from physical or mental disabilities. Eventually, it represents a social class scheme aimed at grouping together people with the same life chances (Maas & van Leeuwen, 2005; Sobek, 2012). Thus, with respect to the theoretical discussion about different social class conceptions introduced above, HISCLASS would fit in the neo-Weberian class concept. Nevertheless, the aim of the authors was not to explicitly construct a class scheme that could be traced back to class theories of Marx or Weber (van Leeuwen & Maas, 2011, p. 17). The aim was rather to build a scheme founded on the common core of underlying dimensions present in classifications used by leading historians in the past, namely, manual/nonmanual, skill level, supervision, economic sector (van Leeuwen & Maas, 2011, p. 26).

In terms of temporal validity, HISCLASS was constructed with the explicit purpose of reliably representing the social class structure from the eighteenth century until the early twentieth century (van Leeuwen & Maas, 2011; p.14). To test its consistency, in an experiment a group of historians independently classified HISCO groups into the HISCLASS scheme, reaching largely the same conclusion (van Leeuwen & Maas, 2011). As far as the latter part of the twentieth century is concerned, HISCLASS has already been used for comparative studies across time and countries, finding stratification for other demographic outcomes such as fertility (Dribe et al., 2017). Moreover, studies have found that HISCLASS for the more recent period yields results similar to those of other more recent classification schemes. For example, the mortality differentials shown by Bengtsson and colleagues (2020) using HISCLASS are comparable to those of Torssander and Erikson (2010), who used the official Swedish occupational classification (similar

to Eriksson and Goldthorpe's (1992) EGP scheme), essentially suggesting that the validity of HISCLASS may be extended to more recent years. Furthermore, the HISCLASS structure allows for different levels of aggregation of the original twelve social classes (see for example Maas & van Leeuwen, 2005, p. 280). Eventually, the analyses presented in the papers are based on more aggregated groupings (that will be described in more detail below), which contribute by removing some of the inconsistencies over time in the meaning of more detailed class schemes.

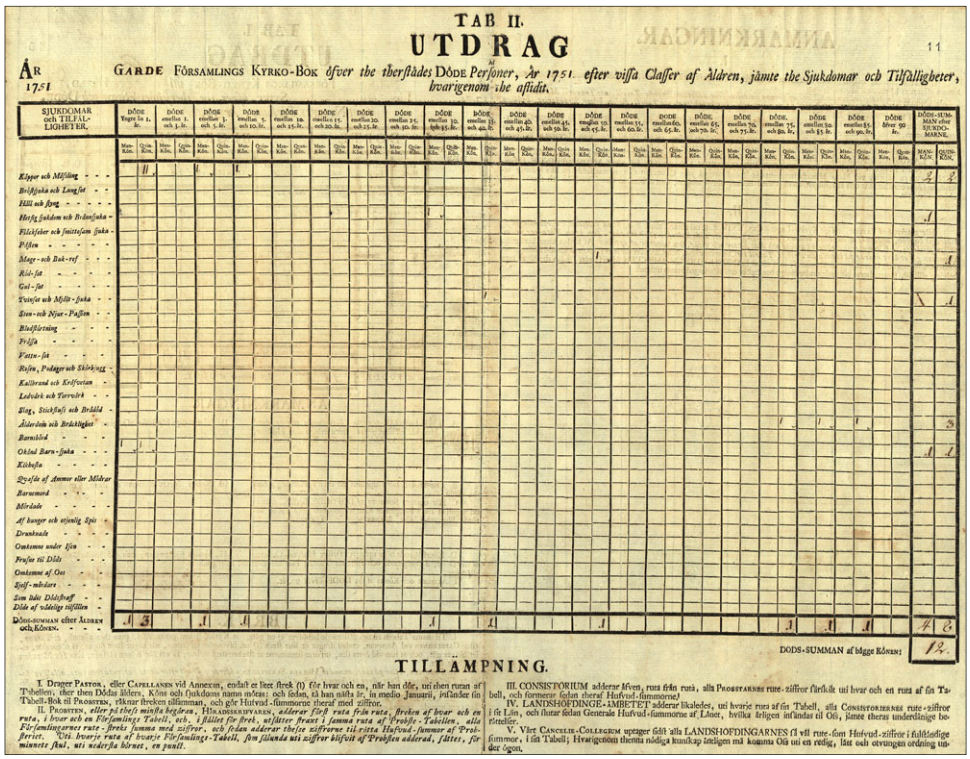
In summary, on a more theoretical level the literature summarized above suggests that social ranking has been fairly stable over time and space independently of the measure used to construct the ranking. Particularly when using broad categories, occupational hierarchies do not change. Additionally, empirical studies using HISCLASS as measure of social class over a long period of time have shown that it provides reliable results.

About the reporting of causes of death before the modern national registers

One of the unique features of the SEDD is that it contains not only information about when and where individuals died but also the underlying causes of death. While this provides an important opportunity to study cause-specific mortality over a long period of time, it also raises some questions and comes with some challenges that are worth discussing. Mainly what needs to be established is the reliability of the information at hand. To address this type of concern there is the need to provide a detailed description of the source, of the people in charge of reporting the information in the source, and of how it has been made available in a format that can be compared with modern registers.

The reporting of causes of death dates back to the 1749 with the creation of the Tabular Commission (*Tabellverket*) aimed at tracking demographic information by means of three types of tables designed by the Royal Academy of Sciences: one table for baptisms and burials, a second table for causes of death, and an additional table that resembled a census with information about civil status and social standing (Rogers, 1999). As far as the second table is concerned, namely, the one regarding the causes of death, it consisted of a form with a list of 33 causes of death by age and sex (Figure 6). The diseases listed in the form (see Figure 7) were intended to capture the most common causes of death of the time and to track their development among the population so that appropriate measures could be taken (Rogers, 1999). This reporting system at the aggregate level relied on individual-level population registers that the clergy kept in each parish recording births, marriages, and deaths (Sundin, 1996). While in the earlier period, it had only been done occasionally, with the establishment of the Tabular Commission the clergy were required to report that information on a regular basis (Sundin, 1996). Between 1749 and 1830, the forms

provided by Tabellverket were updated every 25 years. The changes involved mainly the substitution of infrequent causes of death with new ones (Rogers, 1999).


TAB II.

UTDRAG

11

ÅR 1751

GARDE FÖRSAMLINGS KYRKO-BÖK öfver the therstädes DÖDE Personer, År 1751. efter vissa Classer af Åldren, jämte the Sjukdomar och Tilfälligheter, hvarigenom the afsidit.

TILLÄMPNING.

I. Drager Pastor, eller Capellanen vid Annexum, endast et lineer streck (|) för hvar och en, när han dör, uti then ruran af Tabellen, ther then Dödas ålders, Kön och Sjukdoms namn möras: och sedan, då han nästa år, in medio Januarii, inlämnar sin Tabell-Bok til Prosten, räknar hvarken sämmman, och gör Hufvud-summorne therof med siffror.

II. Prosten, eller på thess minsta begäran, Häradsskrifvaren, adderar först ruta från ruta, streken af hvar och en ruta, i hvar och en Församlings Tabell, och, i stället för dem, sätter svart i samma ruta af Prosts-Tabellen, alle Församlingarnes rutor-streks summa med siffror, och sedan adderar thesse siffrorne til rätta Hufvud-summor af Prosteriet. Uti hvarje ruta af hvarje Församlings-Tabell, som sålunda uti siffror blifvit af Prosten adderad, sätter, för minnets skull, uti nedersta hörnet, en punkt.

III. CONSISTORIUM adderar likaledes, uti hvarje ruta af sin Tabell, alla Prostarnes rute-siffror förskilt uti hvar och en ruta af sin Tabell, och formerar sedan theraf Hufvud-summorne.

IV. LANDSHÖFDINGE-AMBETET adderar likaledes, uti hvarje ruta af sin Tabell, alla Consistoriernes rute-siffror i sit Län, och flutar sedan Generale Hufvud-summorne af Länet, hvilka årligen inlämnas til Oss, jämte theras underdånige berättelser.

V. Vårt Cancelie-Collegium uptager sedt alla Landshöfdingarnes så väl rute-som Hufvud-siffror i fullständige summor, i sin Tabell; Hvarigenom thenna nödiga kunskap årligen må kommna Oss uti en redig, lätt och otvungen ordning tillhanda.

Figure 6: example of the first table II created by Tabellverket.
On the left, there is the list of diseases to be reported in each row. The columns are divided into age groups, which are further subdivided by sex. Source: https://riksarkivet.se/statistiska-tabeller

The recording of population statistics was seen by the clergy as an increasingly burdensome job which resulted, between 1830 and 1860, in only a limited number of causes of death for which tracking was required. Essentially vicars were now required to report deaths from smallpox and other widespread epidemics (mainly cholera), as well as deaths related to childbirth and certain external causes such as murders, suicides, and several accidents (Rogers, 1999). Although the aggregate forms were revised, the registration in the nominal parish registers continued ongoing in most parishes (Sundin, 1996). However, this may have been dependent on the individual parish ministers. As shown by Bengtsson (1988) for the parish of Västanfors, after 1830 the registration of causes of death continued, but when a new minister arrived in 1841 the number of deaths recorded with no description of cause increased as the updated instructions were followed.

TABLE I

Official Classification of Causes of Death in Sweden, 1749–1774

1. Smallpox and measles
2. Chest disease and consumption
3. Chest pains (stitch and sting)
4. Fever fits
5. Typhus and contagious diseases
6. Plague
7. Stomach ailments (gripe)
8. Dysentery
9. Jaundice
10. Atrophy and hysteria (melancholy)
11. Renal calculus (kidney stones)
12. Hemorrhage
13. Ague (malaria)
14. Dropsy
15. Erysipelas, gout and scurvy
16. Gangrene and cancer
17. Rheumatism (synovitis)
18. Stroke and sudden death
19. Infirmities of old age
20. Childbirth
21. Unknown children's disease
22. Whooping cough
23. Suffocation by nurse or mother
24. Infanticide
25. Murder
26. Hunger or unfit food
27. Drowning
28. Died under the ice
29. Frozen to death
30. Died of fumes
31. Suicide
32. Executed
33. Died of dangerous circumstances

Figure 7: list of diseases in the first version of table II created by Tabellverket (translation of the diseases displayed on the left of Figure 5).
Source: Rogers, 1999 page 196

In the decades between 1860 and the beginning of the twentieth century the regulation for reporting causes of death was changed following the establishment of a new central authority: the National Central Bureau of Statistics (Rogers, 1999). One of the most important changes was that all the deaths in cities had to be reported through a death certificate signed by a physician. There was a similar requirement for all deaths in other towns where a physician was present (Rogers, 1999). In 1911, the next important development occurred when the objective of recording the cause of every death was resumed, extending the mandatory reporting from cities to rural areas (Nyström, 1988). Thereafter the continuity of cause-of-death recording continued more consistently in terms of number of deaths with the respective information. Relevant changes were more focused on the nomenclature, which changed in 1931 when a new classification based on the existing Swedish System was implemented in all Nordic countries; this remained in place until the 1950s when Sweden joined the international classification of diseases (ICD) system of the World Health Organization, implementing the 6th version (Rogers, 1999).

While between 1830 and 1860 the aggregate reporting saw a setback in its continuity, it seems that the individual-level registers that are the source of

information for the analyses in the following chapters reported causes of death in relatively continuous manner. Now it remains to be understood the level of reliability of the information.

As hinted above, the recording of causes of death in rural settings during the nineteenth century was accomplished by clergymen. At first, the fact that there were not medically trained persons in charge of the task may decrease the reliability of the information. However, there are several aspects that speak in favor of the quality and of the ability of the clergy that should be borne in mind. First, the clergy did have basic medical training in medicine (Rogers, 1999). Even though on a theoretical level they did not have full knowledge, it was likely that they were able to compensate with practical experience. On the one hand, the local parish minister knew his parishioners well, including their health status. On the other hand, they were often those with the highest education, giving medical advice and treatment and were also invited to participate in discussions related to diagnosis and correct reporting of causes of death (see Bengtsson, 2002; Rogers, 1999). To facilitate their acquisition of knowledge, there was also medical literature specifically aimed at the clergy (Puranen, 1984) and priests often had handbooks in lay medicine in their libraries (Sundin & Willner, 2007). Therefore, some scholars maintain that even though it was a challenge to report the cause of death, the judgments of some priests was probably not that different from those that a professional doctor would have reported (Sundin & Willner, 2007; p. 67).

Surely, the importance of the difference in knowledge between the clergy and the physicians decreased in time. As noted above, as early as 1860 in cities and from the early twentieth century in the countryside, death certificates had to be signed by a medical doctor. In particular, in rural areas, from 1911 all death certificates were checked by the district physician (*provinsialläkare*) who made sure that the information provided was adequate and not ambiguous (Hiltunen & Edvinsson, 2018).

Taken together, from this summary of the available literature on the reporting of causes of death in historical settings emerges the conclusion that the information is fairly reliable. Clearly, the underlying supposition is that the Swedish clergy was reasonably able to diagnose why someone died. Overall, the impression is that there was no difference in diagnostic ability between the clergy and medical professionals (Rogers, 1999; Sundin & Willner, 2007). With due consideration, the material can therefore be useful in investigating the relations of diseases and other health-related variables since the early nineteenth century (Rogers, 1999)

Coding of historical causes of death into ICD-10

Causes of death found in text form in Swedish historical parish registers have been translated into ICD-10 codes as a part of the SwedPop project, which is a national research infrastructure aimed at providing access to harmonized historical microlevel data from Sweden (swedpop.se). More specifically, the coding procedure was developed and implemented at the Center for Demographic and Aging Research (CEDAR) at Umeå University, and a detailed description is provided by Hiltunen and Edvinsson (2018).

The main challenges involved in categorizing and homogenizing historical causes of death within a contemporary coding scheme such as the ICD were mainly related to changes in the historical, geographical, and medical contexts, as well as developments in the medical vocabulary and spelling variants of the same disease. An example of how the historical period can influence the interpretation of a certain cause of death is given by the deaths due to "*slag*" (Sundin & Willner, 2007, p. 86). While in the modern context this indicates a stroke, in the past it was also used in some cases of death in infancy, supposedly indicating sudden death (Bengtsson, 2002). There were also geographical variations in the meanings of certain causes of death. For example, "*ris*" would be used to describe rickets; however, in certain parts of the country it would refer to the symptoms of "fading away" among children (Hiltunen & Edvinsson, 2018). Additionally, in the earlier period, in some instances the reported diagnosis would reflect a set of symptoms rather than a disease; at the same time the medical vocabulary has been continuously developing with the introduction of new terms while others became obsolete and no longer used (Hiltunen & Edvinsson, 2018). Even though these examples represent serious difficulties, and it could be argued that it would not be possible to overcome them, the causes of death contained in historical registers constitute valuable information and provide an opportunity to deepen our understanding of the development of mortality over time, acknowledging that results are interpreted taking into account possible limitations (Arrizabalaga, 1999; Kippen, 2011; Padiak, 2004; Risse, 1997).

The approach adopted in order to address possible differences in meaning of a certain cause of death was to code it according to the most common and accepted meaning of a given designation (Hiltunen & Edvinsson, 2018). In other words, the context does not determine the assigned code. At the same time, ambiguous cases have been documented so that the researcher can be aware of them.

Practically, the coding procedure consists of several automated and manual steps. First, the original text describing the cause of death is split in order to separate different diseases or causes reported in the same string. This is done by identifying specific characters (e.g., "+", "B", "(2)") or words (e.g., "primary", "secondary", "contributing") indicating different components of the string (Hiltunen & Edvinsson, 2018). Then, a string-matching algorithm is used to link the separated strings to an ICD code. In this step, there are three possible scenarios. The string

from the historical records can be a perfect match with an ICD disease. Otherwise, the historical string did not match any ICD disease but could still be placed within an ICD chapter and block. For example, “chronic pneumonia”. was a diagnosis relatively common in the nineteenth century and is considered to represent tuberculosis of the lungs by contemporary physicians; therefore, it was included in the ICD block respiratory tuberculosis (ICD chapter 1, block A16). Those strings that could not be placed in any ICD block were given new codes outside the ICD system, and this had two possible ramifications. On the one hand, from an ICD perspective, these causes of death strings would be categorized as ill-defined. On the other hand, researchers interested in certain research questions tracking historical causes of death could use such newly introduced codes to differentiate among information related to age (old age, infant death), the time dimension (sudden, after a certain period of illness), or place of death (found dead in the mountains/lake/river) (Hiltunen & Edvinsson, 2018).

Following these automated steps, the residual strings that remained unmatched were analyzed manually in a similar fashion. That is, the manual coding procedure entailed both a splitting phase in which strings were divided in case more than one cause of death was present, as well as a coding phase in which the cause of death in text form was given an ICD code.

Looking at the SEDD in greater detail, Figure 8 shows the percentage of deaths observed with a reported cause in text form in the historical registers. It should be noted that the trend follows changes in legislation mentioned in the previous section. There is a decrease in the reporting during the second half of the nineteenth century, when it was not mandatory for priests to record a cause for every death. During the 1880s and 1890s, the numbers of causes of death reported began to increase again, and then from the beginning of the twentieth century almost all deaths were recorded with a corresponding diagnosis.

Figure 9 provides an indication of the coding process performance by showing the percentage of deaths with a reported cause that was translated into an ICD code separately from the ill-defined causes (i.e., referring to age or symptoms). Before 1840, approximately 70% of deaths were assigned an ICD code, then the percentage decreased to approximately 40% during the rest of the nineteenth century. Since the beginning of the twentieth century, approximately 90% of deaths in the dataset have a corresponding ICD code.

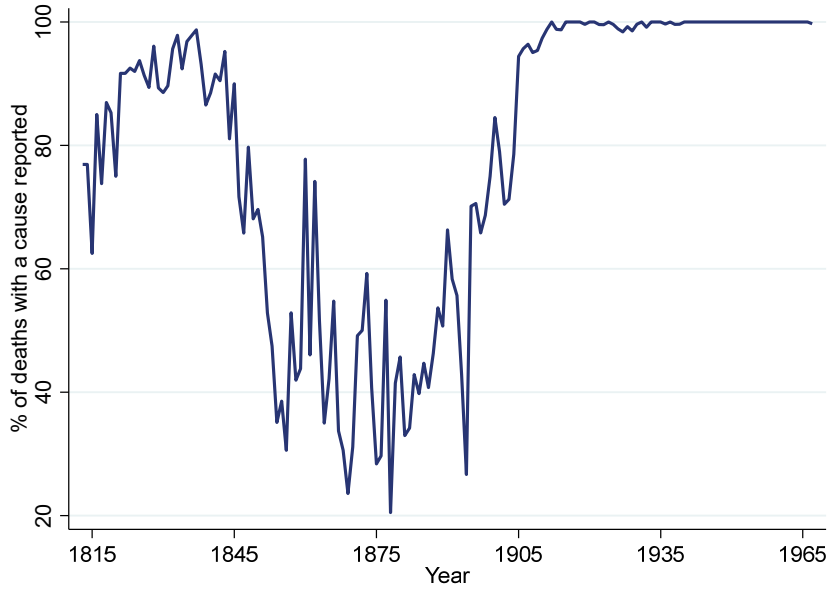


Figure 8: percentage of deaths observed with a reported cause in text form in the historical registers.

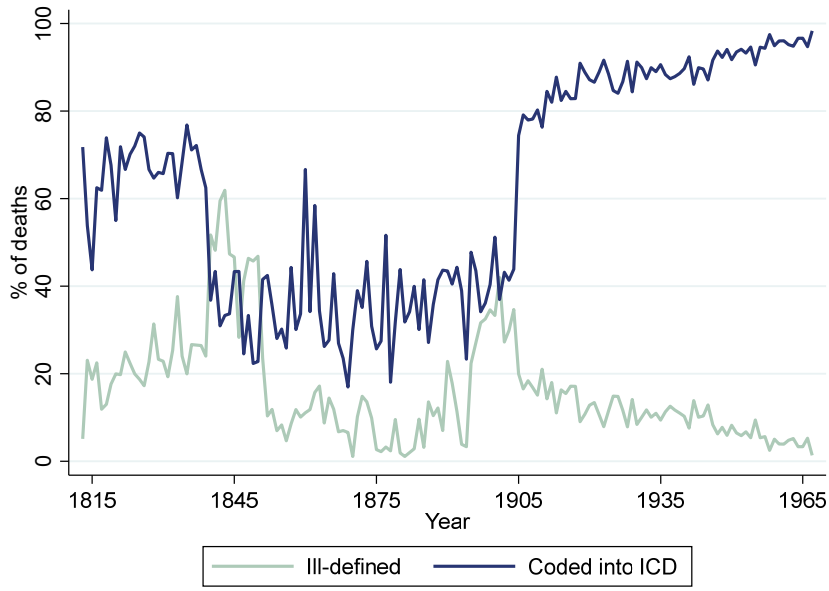


Figure 9: percentage of deaths with a reported cause that was translated either into an ICD code or as ill-defined

Methods

Data management

Since its first version, the SEDD has been continuously expanded and improved. The complexity involved in the management of a dataset with an increasing number of observations (individuals) and variables called for a systematic organization of the data that would provide a suitable platform for efficiently managing the information. At the same time, in recent years, other historical datasets following individuals through their lives and sometimes across generations from various countries have been created and developed[4], raising the issue of comparing life courses across different settings (Alter et al., 2009). Therefore, with the aim of providing a common structure for organizing different datasets and the different types of information included in them, the Intermediate Data Structure (IDS) was proposed as a way to standardize the dissemination of the data as well as to foster development and sharing of software for data analysis (Alter et al., 2009; Alter & Mandemakers, 2014). Essentially, the IDS provides a standardized format that can be applied to all databases and consists of two parts, a first part (*data transfer)* in which data from the original dataset are reformatted into the IDS form, and a second part (*extraction*) in which the dataset can be moved into a file designed for analyses (e.g., an episode file for survival analysis) (Alter et al., 2009).

The SEDD has been adopting the IDS structure, and software has been developed to extract the information and organize it in an episode file format (Quaranta, 2015, 2016). One of the features of an episode file is the so-called long format, indicating that the data are structured in such a way that there are many observations for a single individual. A new observation is introduced any time that a "life event" happens to the subject (e.g., marriage, migration, birth of a child, change in occupation, death). A particular characteristic of the SEDD's episode file, which is relevant for the work in this thesis, is related to occupational variables. The SEDD includes occupational information from different sources. On the one hand, it can be found in population registers that were updated annually; on the other hand, occupation was also registered concomitantly with certain events such as marriage. How were multiple variables with multiple observations managed? It is a two-step process. First, in case of different information at the same time point, there was the need to choose only one occupation. This was accomplished by assigning a HISCLASS value to every occupation and by retaining the minimum, which would indicate the highest social class. The second step was to address instances in which

[4] See, for example, the Demographic Database from northern Sweden (https://www.umu.se/en/centre-for-demographic-and-ageing-research/databases/), the Historical Sample of the Netherlands (https://iisg.amsterdam/en/hsn) or the Utah Population Database (https://uofuhealth.utah.edu/huntsman/utah-population-database/).

an occupation (and therefore a HISCLASS value) was available only for certain observations; i.e., only at certain time points. In this case, the rationale used was to assign the latest non-missing HISCLASS. For each individual, through time, this was done by retaining the previously recorded social class in case at a certain point in time the information was missing. If the information would be retained for too long this could raise some concern, as the older the information the less reliable it might be. In this regard it is worth noting that over 80%[5] of the HISCLASS values for both men and women between 30 and 60 years old were within two years since recording and almost 90% within five years.

Statistical methodology

Cox regression

The data described above have been analyzed using a variety of statistical methods across the four papers. The first two studies use survival analyses to exploit the longitudinal nature of the dataset, organized as an episode file. Cox regression models are estimated to obtain the mortality hazard for different groups of interest (e.g., social class, income level) while adjusting for other covariates and for the selected underlying time scale. A Cox regression model can be written in equation form as follows:

$$h(t) = h_0(t)\exp(b_1X_1 + b_2X_2 + \cdots + b_iX_i)$$

The expected hazard h at time t includes two main components, the baseline hazard $h_0(t)$ and the exponentiated linear combination of the predictors. The baseline hazard is the hazard when all the independent variables are set to 0. Results are presented in the form of hazard ratios, which indicate the expected change in the mortality hazard following a change in the variable of interest with respect to the reference category, holding the other covariates constant. Coefficients higher than 1 are suggestive of an increased hazard, while coefficients less than 1 suggest an expected reduced hazard. Cox regressions are classified as semiparametric models indicating that, on the one hand there is no assumption about the baseline hazard function, but, on the other hand, the assumption of proportionality of hazards must be met. That is, changes in the variable of interest result in proportional changes in the hazard, regardless of the baseline timepoint. For example, the analyses in study one and two use age as a baseline time scale. If the proportionality of hazard

[5] This figure refers to the social class recorded for the family head. Social classes referring to the specific individual are also available. In this case, more than 87% of the information is within years for men aged 30 to 60 and almost 55% for women in the same age group. Each individual was assigned to their respective individual social class. If the subject was also the family head and if the recorded family head social class was higher than the individual one, then the family head social class was used.

assumption is violated, each estimated coefficient is still interpretable as a weighted average of the independent variable effect over time. However, it is not possible to capture how such effect varies with age (or the chosen baseline time scale). An extreme case is when the hazards cross each other, as it means that there will be an opposite effect depending on the age range so that a predictor having a positive association with the outcome at a certain point in time will be negatively associated with it at another point in time. The proportionality of hazards is assessed using both a test based on scaled Schoenfeldt residuals and log-log plots of the survival probability.

Logistic regression

The third study use logistic regression to estimate the association between a certain occupation indicated in the population census and death within the next ten years. Such a statistical method is commonly used when the outcome of interest is binary and allows estimation of the change in odds of the outcome given a change in the exposure of interest, while adjusting for a set of covariates. Each coefficient is presented as an odds ratio, which indicate the odds of dying within ten years for a certain occupation compared to the odds of dying within ten years in the reference category. As with hazard ratios, an odds ratio higher than one indicates an increased occurrence of the event, while an odds ratio lower than one suggests a reduced occurrence of the event.

Age-Period-Cohort analysis

The fourth study uses a set of techniques to disentangle age, period, and cohort effects relative to SES differences in mortality. The linear combination of the three components poses a mathematical challenge, as, in a regular regression setting, it would result in multicollinearity issues. Several methods have been proposed to address this problem, and they can essentially be distinguished in terms of the assumptions on which they rely (see, for example, Fosse & Winship, 2019). The first model used in the fourth study is a constrained Poisson regression. In this framework, the estimation is made possible by setting two age/period/cohort groups equal to zero. Each time effect is then separated into a linear trend (overall slope) and a curvature. The results are presented in terms of such curvatures or departures from linearity that can be uniquely estimated and represent, for each time point, the deviation from the expected trend. The intrinsic estimator (Yang et al., 2008) was used to check the sensitivity of the results to a different method.

Summary of Papers

Paper 1: SES inequalities in cause-specific adult mortality: a study of the long-term trends using longitudinal individual data for Sweden (1813-2014)

SES is associated with better health and lower mortality in most developed societies currently, including countries such as Sweden, with a developed welfare state. To better understand the mechanisms that link SES to mortality, this paper examines SES differences in cause-specific adult mortality for men and women from 1813 to 2014 and focuses on when these differences emerged.

The analyses are based on version 6 of SEDD (Bengtsson et al., 2017), which includes individual-level longitudinal demographic and occupation information for five rural and semi-urban parishes and a port town in Skåne, the southernmost region of Sweden. Individuals were followed across generations from 1813 until 2014, although part of the data (for the port town of Landskrona) starts in 1922. The entire period was divided into four sub-periods, which partly reflect changes in data sources and availability, and partly captures societal and environmental changes in the studied population: 1813-1921, 1922-1967, 1968-1989, 1990-2014. Social class was used to indicate SES and was coded using the HISCLASS scheme (van Leeuwen & Maas, 2011). More specifically, the analyses were firstly carried out using a three-classes grouping: nonmanual (HISCLASS 1 to 5), manual (HISCLASS 6 to 12 excluding 8) and farmers (HISCLASS 8). A more detailed grouping considering six classes was also used distinguishing between higher managers/professionals; lower managers/professionals/clerical; foremen and medium skilled workers; lower skilled workers/farm workers; unskilled workers/farm workers; farmers and fishermen. The outcome variable was cause-specific adult mortality, from age 30 to 90. Two causes of death grouping were adopted. Firstly, causes of death were classified into preventable and non-preventable, following the Avoidable Mortality in the European Union (AMIEHS) classification (see also Ericsson et al., 2019). Second, causes of death were categorized following the ICD chapters: (1) infectious and parasitic diseases, (2) circulatory diseases (3) respiratory diseases (4) other cancers (5) external causes (6) other and ill-defined causes of death and (7) missing causes of death.

Estimates for the effect of social class on the mortality hazard from a specific cause of death were obtained using Cox regressions. Analyses were performed separately by period and by sex. Each model, was further adjusted for birth year, marital status, and parish of residence. In addition, migration status was also included in the second, third, and fourth periods.

Results show that non-manual workers had lower mortality due to both non-preventable and preventable diseases in men and women in the last two periods, consistently with other studies based on a national Swedish sample (Ericsson et al., 2019). In the first two periods, there was no statistically significant association

between SES and mortality for non-preventable mortality. In the second period, men in the non-manual group had higher mortality, while women in the non-manual group had lower mortality from preventable causes.

When looking at more detailed groups of causes of death, in the last two periods both men and women in the non-manual group had lower mortality across all causes, which is in line with other studies for the whole country (Erikson & Torssander, 2008; Kunst et al., 1998; Toch-Marquardt et al., 2014; Weires et al., 2008). With the exception of a lower infectious disease mortality for women in the non manual group in the second period and of a higher circulatory disease mortality for men in the non manual group in the first two periods, before the late 1960s there were no statistically significant differences in mortality by social class.

This study shows that social class differences observed nowadays have emerged only in the last fifty years for men and women and for all causes of death. The observation of a positive association between social class and circulatory mortality for men before 1968 suggest the importance of lifestyle as a potential mechanisms and challenges the fundamental cause theory and the view that mortality differentials by SES have always been there.

Paper 2: Has it Always Paid to be Rich? Income and Cause-Specific Mortality in Southern Sweden 1905-2014

A clear health and mortality gradient by socioeconomic status is found regardless of which dimension of socioeconomic status is used (e.g., Cutler et al., 2012). While most research has analyzed the association with mortality using education or social class (see, e.g., Cutler & Lleras-Muney, 2008; Mackenbach et al., 2016), the literature focusing on income is more limited (Chetty et al., 2016; Hederos et al., 2018; Kondo et al., 2014, 2014; Torssander & Erikson, 2010; Wamala et al., 2006). In particular, the large majority of these studies that analyze mortality differences over time have mainly focused on the period since 1990, and only a portion of them consider cause-specific patterns. For Sweden, for example, it seems that mortality inequalities by income have widened and that such development is especially related to circulatory diseases, alcohol-related diseases and some forms of cancer (Hederos et al., 2018). Research on the long-term trends of socioeconomic differentials in mortality that considers the period before the 1970s has almost exclusively focused on social class, and there are no previous studies concerning the long-term association between income and cause-specific mortality.

This paper analyzes the relationship between income and adult cause-specific mortality during the period 1905-2014 in an area of southern Sweden. The analyses are based on version 7.1 of the SEDD (Bengtsson, Dribe, Quaranta, et al., 2020), which contains individual-level longitudinal data on cause-specific mortality, occupation and individual income throughout the period. The period is divided into five subperiods 1905-1921, 1922-1949, 1950-1967, 1968-1989, and 1990-2014.

Throughout this time frame, the reporting of income has undergone several changes following the developments of the tax system. In particular, before 1947, the income of married women was included in their husbands' tax returns. Income and tax declarations of married couples were then gradually separated until 1971, when Sweden stopped practicing joint taxation of married spouses. Another relevant feature of the tax system is that there were income thresholds below which income did not need to be reported. This is particularly relevant for the initial period, as the thresholds remained fairly constant over time, and therefore an increasing number of people fell above them and were required to declare their income (Helgertz et al., 2020).

A family income in which earnings of both spouses were added together was calculated in order to have a comparable measure over time. Eventually, income quintiles were used to measure exposure in the models. Following the procedure in Hederos et al. (2018), the three-year average of the residuals from a fully interacted regression of income on birth cohort, year, and sex was used to assign each individual in each year to the corresponding income quintile group.

The study models the relationship between income quintiles and total and cause-specific adult and old age mortality for different subperiods. Cox regression models were used to estimate the hazard of death from specific causes adjusting for birth year, marital status, parish of residence, and migrant status. Furthermore, separate models were run for men and women and for each subperiod. An additional set of regressions further adjusted for social class was estimated.

Results for the period since 1970 confirm previous findings for Sweden by Hederos et al. (2018) and offer new evidence on when the income gradient in adult mortality emerged, which was not until after 1950. Furthermore, the income gradient in adult mortality emerged almost simultaneously in all analyzed causes of death: starting with infectious diseases and then appearing in circulatory and respiratory ailments, cancers, and external causes.

Paper 3: Differences in All-Cause Adult Mortality by Occupation Using Full-Count Data from Sweden, 1880-2001

Common measures used to capture the social stratification within a society are income, education, and social class. When using social class to measure SES, several studies have used a categorical indicator based on occupations, creating what could be termed "occupation class". Most often this entails grouping together jobs according to the required skills and supervision levels, and sometimes accounting for geographical location such as rural vs urban (Elo et al., 2014; Mackenbach et al., 2003; Marmot et al., 1991; Toch-Marquardt et al., 2014; van Raalte et al., 2014). The advantage of this approach is that it helps capture overall patterns of associations between an outcome (e.g., mortality) and broad SES categories. However, doing this leads researchers to overlook the links between more detailed

measures of occupation and mortality. Research on the impact of more detailed measures of occupation has found differences in mortality for specific jobs that could not have been discovered using other broad social class measures. Nevertheless, findings are scattered (Johnson et al., 1999; Katikireddi et al., 2017; Woods, 2000). Focusing on mortality differences by specific occupational categories could also help identify relevant mechanisms linking SES to mortality. In addition, it is important to investigate long-term developments in order to examine how social determinants of mortality might have changed through time.

This paper investigates the link between occupation and all-cause adult mortality in Sweden, analyzing individual- and household-level information covering the entire Swedish population in the years 1880, 1890, 1900, 1910, 1950, 1970, 1980, 1990, and 2001. Such data have been linked to death registers in order to obtain the follow-up information about mortality.

A set of logistic regressions is estimated separately for men and women aged 30 to 60, at each point in time, to obtain the odds of dying within ten years since each observation. Models were adjusted for marital status, birth year fixed effects and place of residence fixed effects. The analyses were performed, first, by broader occupational groups (e.g., professionals, administrative, clerical), resembling a stratification by social class, and then by smaller groups (e.g., health professionals, teachers, etc.), which constitutes a more detailed classification of occupation.

The results show that within broad occupational groups, mortality differed depending on the specific occupation. For instance, health professionals, creative professionals, and aircraft and ship officers show a consistently higher mortality than teachers, particularly for men. Similarly, blue-collar men, miners, drivers, material handling workers, and food/beverage/tobacco workers showed elevated mortality. Some occupations showed higher mortality only in the period before 1970, mainly white-collar jobs for men such as business professionals, legal professionals, and managers.

As in the previous two papers, lifestyle is likely a key factor which could explain differences not only between but also within social classes. In addition, the results suggest a higher risk of mortality, regardless of social class, for occupations with higher job strain, as in working outside regular business hours.

Paper 4: Period and Cohort Trends in Social Class Inequalities in Adult Mortality: Evidence from Southern Sweden 1905-2014

A large portion of the literature on the SES-mortality relationship is limited to a period perspective, and consequently possible cohort effects are not fully considered. This implies that the focus is only on those changes and events that simultaneously affected individuals across all age groups, providing only a limited view on development over time. In doing so, age-specific mortality risks are compared between calendar periods, disregarding differences across cohorts, and

therefore changes in mortality may be improperly attributed to period factors. While period factors include events and processes that happened in history and that affected the entire society regardless of their age, cohort effects refer to certain experiences or events that affect specific cohorts and that persist throughout the courses of their lives (Alwin & McCammon, 2003). For example, a decrease in mortality may not only be dependent on medical interventions applied in a given period but also on the fact that children born more recently underwent better nutrition and public health practices that were put in place earlier in their lives resulting in improved physiologies (Fogel, 2004). Several empirical studies have shown the importance of cohort effects when studying SES differences in health outcomes such as obesity (Heo et al., 2018) and mortality (Masters et al., 2012, 2015).

This paper investigates period and cohort trends net of each other and of age effects in the relation between social class and adult mortality. Data included in version 7.1 of the SEDD (Bengtsson, Dribe, Quaranta, et al., 2020), providing information about all-cause adult mortality and social class in individuals between 30 and 90 years old from southern Sweden covering the period between 1905 and 2014, is analyzed using a set of constrained Poisson regressions run separately for men and women. Given the possible sensitivity of the results to the chosen estimation method (Masters & Powers, 2019), period and cohort effect are also evaluated using the intrinsic estimator method (Yang et al., 2008).

Results suggest that the 1960s was the period in which, for men, mortality in the nonmanual social class relative to the manual group shifted from being higher to being lower, and in which, for women, the mortality gap between the two social classes widened. Furthermore, cohort effects seem to have played an important role in mortality development. This finding indicates that mechanisms linked to cohort changes, such as lifestyle and early life exposures, are likely explanations for the relationship between SES and mortality.

Discussion and Conclusion

The overarching aim of this thesis was to explore the development of SES differences in all-cause and cause-specific adult and old age mortality over the last 200 years, exploiting unique longitudinal individual-level data for a regional population in the south of Sweden, as well as full-count decennial microcensuses for the whole country. The objective was to shed light on whether the social gradient in health that has been extensively found in contemporary societies has always been present or not. More specifically, the added value of the empirical work presented in the next chapters consists in the ability to study longitudinally the associations between different dimensions of socioeconomic status and different causes of death.

On the one hand, consistent evidence of a socioeconomic gradient in mortality in recent years and the formulation of the fundamental cause theory (Link & Phelan, 1995) may lead to the expectation that this has always been the case. On the other hand, previous to this thesis, sparse evidence and theoretical considerations about historical populations and contexts have been employed to argue differently (Bengtsson & Dribe, 2011; Razzell & Spence, 2006). This thesis brings to light several relevant findings and engages in the literature about SES inequalities in adult mortality by showing long-term developments and discussing potential mechanisms driving the level of inequality.

As presented above in the introduction, the underlying aim shared by all four papers was to study the timing of the emergence of the SES gradient in mortality. It was confirmed throughout all the studies that the socioeconomic gradient in mortality is a recent phenomenon starting after the second world war. This result was independent from the dimension of socioeconomic status used in the analysis. A similar late emergence of social differences in mortality dating back to not earlier than the 1950s is evident regardless of whether the analysis was based on social class or income (studies one and two). Even when examining more detailed occupations (study three) throughout the whole country, more prestigious jobs such as architects, engineers, physicians, and lawyers were not associated with lower mortality before the second half of the twentieth century. When using a more refined period subdivision of the twentieth century as in study four, the results suggest that for both men and women the 1960s was the decade in which the mortality gap between the higher and lower SES groups significantly widened.

The goal of research questions two and three was to examine the SES-mortality relationship in greater detail by studying patterns of both social class and income and by analyzing different causes of death. Both when looking at social class (study 1) and income (study 2), the timing of emergence was strikingly similar across all the causes of death considered. Analyzing nonpreventable versus preventable causes of death or more specific groups of diseases showed that the advantages related to one's higher social class or to one's higher income appeared at approximately the same time and did so regardless of preventability. One exception is that higher income for men and higher social class for women seemed to be protective factors in terms of mortality from infectious diseases already at an earlier stage. An interesting result was the reversed gradient – both when looking at social class and income – in mortality from circulatory diseases for men during the nineteenth and first half of the twentieth century. More specifically, this finding is particularly informative when considered in light of sex differences, namely, the reverse gradient in circulatory mortality is present for men but not for women.

Taken together, the first two research articles also inform on the variations in the SES-mortality relationship when considering different SES dimensions. First, empirical models including both social class and income showed that they are both independently related to mortality. This was clear in the analyses reported in study

2, which showed a significant association between social class and mortality, while the results for income remained comparable to the models in which social class was not included. Second, the analyses including both dimensions showed that the timing of emergence of the gradient was different. The results indicated that compared to social class, the income gradient appeared at an earlier stage. More specifically, the mortality advantage associated with higher income was evident since the 1950s, while when looking at social class it emerged a couple of decades later.

Using full-count Swedish censuses, it was possible to breakdown the relationship between social class and all-cause mortality by investigating the roles of specific occupations. This was the aim of the fourth research question, and it is addressed in the third study, which showed the degree of heterogeneity in mortality within a social class when considering a more detailed categorization of occupations. In other words, not all individuals in a given social class had the same pattern. In fact, when divided according to their occupation, significant differences arose. For example, among occupations that would be classified as nonmanual, mortality from the late nineteenth century up until the 1950s was substantially higher for managers, health professionals, and creative professionals compared to teachers and religious professions.

Given the importance and the focus of this thesis on developments over time, it was relevant to ask the fifth research question and deepen our understanding of the different roles played by period and cohort factors. As explained in detail in the last paper, separating period and cohort effects can be linked to different mechanisms and therefore may provide useful information about the potential pathways between SES and mortality. What results from such analysis is that cohort factors may have had a greater contribution to explaining mortality patterns by SES.

Considered together, these results had one common denominator that was identified to be lifestyle. Lifestyle factors are consistent with the reverse gradient in circulatory diseases before the 1950s and the turn-around that happened later. Indeed, higher social classes were more likely to be heavy consumers of alcohol, to smoke tobacco and to have a sedentary life. In more recent years, the opposite is true. Moreover, unhealthy behaviors were more common among men, which is a potential explanation for why the reverse gradient is not present for women. Lifestyle factors are more closely related to one's social class, as they are strongly influenced by the social environment in which an individual lives much more than by economic resources. This would explain the more persistent reverse gradient by social class with respect to income and, consequently, the earlier emergence of the income gradient. Differences in lifestyle fit also with the results found in specific occupations. Within the higher social class, teachers and religious professionals, who had the lowest mortality, were those less inclined to bad habits, possibly because of the social control exerted from the community. Last, the relatively strong cohort effects could also be explained by lifestyle factors, as similar behaviors (e.g.,

smoking) are shared by individuals in the same age group when such customs spread.

While there are no detailed surveys looking at consumption patterns for the nineteenth and early twentieth century, there is still some evidence that corroborates a lifestyle mechanism. During the early twentieth century, smoking was seen as habit for sophisticated modern upper and middle class men (Sundin & Willner, 2007, p. 29). Men in lower social classes – farmers, artisans, factory workers – were more associated with the use of snuff, a form of smokeless tobacco that they put under the lip (Nordlund, 2005). Cigarette smoking has been related to socioeconomic status since the habit started to spread in the late nineteenth century (Pampel, 2009). Patterns of diffusion suggest that, as any other fashion or innovation, higher status groups are the first to adopt the new behavior so that individuals, particularly men, in the elite begin to smoke earlier than did other social groups (Ferrence, 1989; Pampel, 2005). For Sweden, even though it does not represent definite evidence about the quantity consumed, according to household budget surveys during the early 1910s, the expenditure for alcohol and tobacco was higher in wealthier households (Socialstyrelsen, 1921). Eventually, smoking being a social habit, it mainly took place in bars and restaurants where higher-SES men socialized, exposing them to both active and passive smoking (Dribe & Eriksson, 2018).

While lifestyle provides a compelling explanation for several of the mortality patterns highlighted in this thesis, other mechanisms must be considered. The lower mortality from infectious diseases related to higher SES may be linked to material resources such as better housing. However, this result does not seem strong, given the observed sex differences, namely, that it is found for men when looking at income and for women when looking at social class.

The patterns that emerged from the different analyses may also partially reflect the role of early life conditions on adulthood outcomes. Infant mortality started to decline earlier for higher social classes. Therefore, children belonging to higher SES groups would be more likely to survive childhood hazardous exposures, potentially leading to scarring effects, which are enduring health consequences, and eventually higher mortality later in life. Among children with lower SES only stronger subjects would live through childhood adverse exposures, possibly resulting in lower adult mortality.

What may be taken away from this thesis is that socioeconomic status has not always been related to mortality in the same way through time. The impact of socioeconomic status depends on which mechanisms each SES group exploits to avoid risk factors at each point in time. While in the recent period higher socioeconomic groups have been able to take advantage of the entire array of health protective dynamics, this was not so in the past.

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