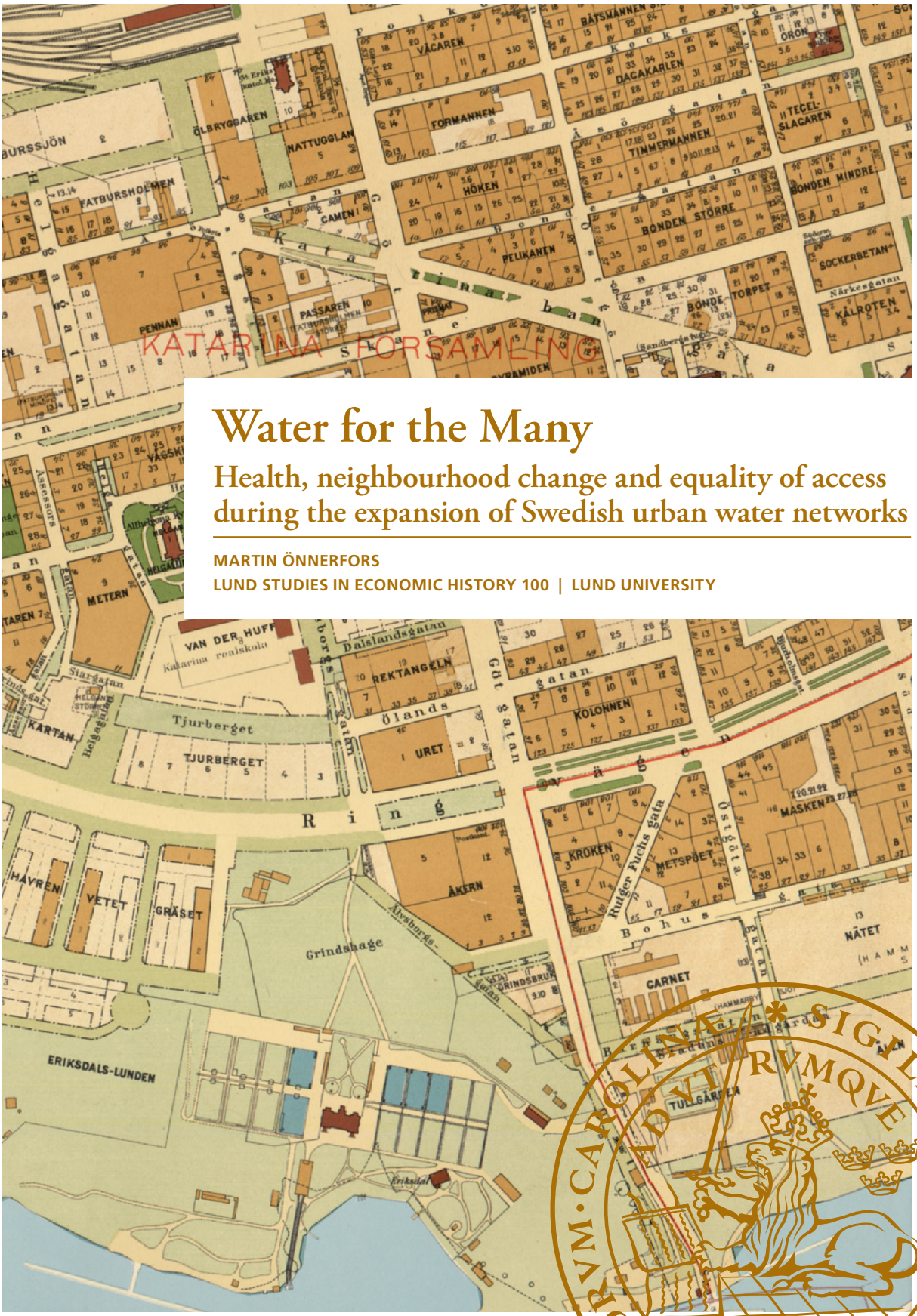
Water for the Many

Health, neighbourhood change and equality of access during the expansion of Swedish urban water networks

Önnerfors, Martin

2021

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



Water for the Many

Health, neighbourhood change and equality of access during the expansion of Swedish urban water networks

MARTIN ÖNNERFORS

LUND STUDIES IN ECONOMIC HISTORY 100 | LUND UNIVERSITY

Water for the Many

Health, neighbourhood change and equality of access during the expansion of Swedish urban water networks

During the course of the late nineteenth and early twentieth centuries, conditions for life in the city changed drastically. Investments in infrastructure, health and education coincided with economic growth, urbanisation and mortality decline. This dissertation uses newly available macro- and micro-level data to examine the consequences and mechanisms of an important investment in cities: the building of water networks. Access to safe water is expected to be positive for health, but the networks can also have unintended consequences for affected neighbourhoods. The results from this dissertation show that water networks, combined with sewerage networks, had a solid but comparatively modest negative effect on urban mortality in Sweden. This is interpreted as an outcome of the small population size of Swedish cities compared to larger cities in previous research, and the early advent of the Swedish mortality decline. Results from the micro-level, investigating mortality effects from access to water in Södermalm, Stockholm, show a similar pattern of comparatively low magnitudes. The micro-level results show that the effect of water access on infant and child mortality is largely removed with the introduction of parental socio-economic status.

Also studying how public investments spread in cities, and how they affect a city's social composition, this dissertation uses building-level data on Stockholm's water network. Results show that Stockholm succeeded in bringing water access to all social classes without creating large inequalities. This stands in contrast to previous results from the UK, where a privatised water sector created large access inequalities. Likely explanations are the choice of a public actor and residential integration between social classes. Further results show that buildings connected to the network experience an upwards change in social composition in the long term. This is interpreted as an outcome of desirability changes of connected buildings, which can in turn affect the possibilities of lower-class residents to live in a connected building. The results of this dissertation show that context and precision in measurements matter for our understanding of how public investments shape life in the city.

Printed by Media-Tryck, Lund 2019 // NORDIC SWAN ECOLABEL 3041 0903

LUND UNIVERSITY

Department of Economic History
School of Economics and Management

Lund Studies in Economic History 100
ISBN 978-91-87793-74-5
ISSN 1400-4860

Water for the Many

Health, neighbourhood change and equality of access during the expansion of Swedish urban water networks

Water for the Many

Health, neighbourhood change and equality of access during the expansion of Swedish urban water networks

Martin Önnerfors

LUND
UNIVERSITY

DOCTORAL DISSERTATION

by due permission of the School of Economics and Management, Lund University, Sweden.
To be defended at EC3:207 on Friday, the 17 of September 2021 at 10:15.

Faculty opponent:
Lionel Kesztenbaum

Organization	Document name
LUND UNIVERSITY Department of Economic History Box 7083 SE–220 07 LUND Sweden	**DOCTORAL DISSERTATION** Date of disputation 2021-09-17 Sponsoring organization
Author(s) Martin Önnerfors	

Title and subtitle

Water for the Many: Health, neighbourhood change and equality of access during the expansion of Swedish urban water networks

Abstract

During the course of the late nineteenth and early twentieth centuries, conditions for life in the city changed drastically. Investments in infrastructure, health and education coincided with economic growth, urbanisation and mortality decline. This dissertation uses newly available macro- and micro-level data to examine the consequences and mechanisms of an important investment in cities: the building of water networks. Access to safe water is expected to be positive for health, but the networks can also have unintended consequences for affected neighbourhoods. The results from this dissertation show that water networks, combined with sewerage networks, had a solid but comparatively modest negative effect on urban mortality in Sweden. This is interpreted as an outcome of the small population size of Swedish cities compared to larger cities in previous research, and the early advent of the Swedish mortality decline. Results from the micro-level, investigating mortality effects from access to water in Södermalm, Stockholm, show a similar pattern of comparatively low magnitudes. The micro-level results show that the effect of water access on infant and child mortality is largely removed with the introduction of parental socio-economic status.

Also studying how public investments spread in cities, and how they affect a city's social composition, this dissertation uses building-level data on Stockholm's water network. Results show that Stockholm succeeded in bringing water access to all social classes without creating large inequalities. This stands in contrast to previous results from the UK, where a privatised water sector created large access inequalities. Likely explanations are the choice of a public actor and residential integration between social classes. Further results show that buildings connected to the network experience an upwards change in social composition in the long term. This is interpreted as an outcome of desirability changes of connected buildings, which can in turn affect the possibilities of lower-class residents to live in a connected building. The results of this dissertation show that context and precision in measurements matter for our understanding of how public investments shape life in the city.

Key words

public investments, mortality, industrialisation, water networks, neighbourhood change, Sweden, Stockholm

Classification system and/or index terms (if any)

Supplementary bibliographical information	Language
	English
ISSN and key title 1400-4860 Lund Studies in Economic History	ISBN 978-91-87793-74-5 (print) 978-91-87793-75-2 (pdf)
Recipient's notes	Number of pages 211 / Price
	Security classification

Water for the Many

Health, neighbourhood change and equality of access during the expansion of Swedish urban water networks

Martin Önnerfors

LUND
UNIVERSITY

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.

Cover illustration front: Stockholms stadsarkiv, Stockholms stadsarkivs kartsamling NS 442, SE/SSA/0234/J 4 A:23. Karta över de centrala delarna av Stockholms stad, Stockholms Stadsingenjörskontor genom A. E. Påhlman och Nils Hanzon 1930.

Funding information: This work was financially supported by the Department of Economic History at Lund University, the Crafoord foundation (project 20140569), Jan Wallanders / Tom Hedelius Stiftelse (project P16-0171) and Stiftelsen Markussens studiefond.

School of Economics and Management
Department of Economic History

ISBN: 978-91-87793-74-5 (print)
ISBN: 978-91-87793-75-2 (pdf)
ISSN: 1400-4860 Lund Studies in Economic History

Printed in Sweden by Media-Tryck, Lund University, Lund 2021

Contents

Acknowledgements

It's said that it takes a village to raise a child, and I can add to this saying that it also takes a whole bunch of people to raise a master student with fuzzy ideas to a finished PhD. The long five years have come to an end, and I'm happy to here acknowledge all the people that have helped me finish.

The PhD supervisor is enormously important for keeping everything on track, and I have a number of supervisors who have been involved in creating this dissertation. In chronological order: first, Jonas Helgertz. I am very grateful to Jonas for believing in me, taking me on as a PhD student, and keeping me moving forward in the beginning of my journey. Jonas introduced me to econometrics, and together we finished the first and only published paper of this dissertation, which I am happy to have been a part of. Second, Anna Tegunimataka. It might sound like a cliché, but it's definitely true that this dissertation would not have been finished if it wasn't for you. The academic help, motivation and emotional support you gave was beyond your role of secondary supervisor, and I will always be grateful for everything that you've done. I can only hope that we will work together again sometime! And last but not least, Anders Nilsson. Anders took over as my primary supervisor during my stormy last year and managed to steer me in the right direction towards finishing. Your calm, experience and sense of humour has been invaluable.

A great number of people at the Department of Economic History and the Centre for Economic Demography have also given important input to the work in progress. I am grateful to Martin Dribe and Finn Hedefalk for providing excellent comments to my draft at the final seminar, as well as all the participants of my fourth paper seminar in April this year. A special thanks goes to Maria Stanfors for supporting me and involving me in her projects.

The office wouldn't run without Anneli Nilsson Ahlm, Christina Rothman, Madeleine Jarl and Tina Wueggerz, who I thank for their time and patience. I also want to thank the head of Department Mats Olsson and director of PhD studies, Ellen Hillbom, for a job well done in keeping track of me and helping me out.

I had the luck and privilege of sharing an office with Luis Serratos for three years before the pandemic forced us to work from home. It is a scientifically established fact that Luis is the best office mate anyone could ever ask for. Not only is he a very gifted economist and an English language expert, he is also calm, extremely organised and a lot of fun to be with. From reminding me of seminars and fixing my equations to bringing me homemade sorbet for my birthday, Luis has brightened my days and been a big part in helping me make it to the end. I can only wish that we will share an office again! I also want to thank Enrico Debiasi and Elien Van Dongen for always having an open door and time for a chat about research and the shared pains of PhD students. Naturally, there are too many

people to mention in the Department and the Centre, but I always appreciated the open and friendly atmosphere over lunch, coffee, and seminars. A special thanks goes out to Finn, who looked out for me during my sick leave – it really did mean a lot.

Utanför akademin har en hel del människor varit viktiga under de fem år som gått. Min kära vän Julia, som varit med på resan ända sedan jag sa upp mig för att börja studera igen, och alla våra vindlande samtal på Metro – kanske hade jag aldrig ens påbörjat det här om det inte var för dig? Min kära vän Ann-Katrin, som alltid funnits tillgänglig för hetsiga samtal om samhället och livets villkor – det har betytt väldigt mycket genom åren. Och en hel massa andra kära vänner som varit med under resans gång, Jon Persson, Evelina, Ola, Cecilia, Björn, Johan, Will och säkert många fler.

Min familj är och har varit otroligt viktig under åren som gått. Mor, som alltid stöttat mig och givit en trygg hamn hemma i Tvetaryd. Far, som försvann alldeles för tidigt och som jag hade velat diskutera så mycket med. Mina syskon Fredrik, Boel, Jacob och Gabriel med familjer, som alltid varit hjälpsamma och bjudit på fina avbrott från arbetet. Speciellt tacksam är jag för min bror Gabriel, som verkligen tog hand om mig när jag var sjukskriven och hjälpte mig komma på fötter igen.

Den som stått mig närmast under den här tiden är såklart min älskade Katarina. Du har givit mig perspektiv och kärlek och sett till att jag fokuserat lite mindre på avhandlingen i tider då jag behövt en paus. Tillsammans med dig och den lilla som just nu bor i magen ser jag ljust på framtiden.

Bagarmossen, Juli 2021

Martin Önnerfors

List of papers

This thesis is based on the following papers, referred to by their Roman numerals:

I **Public Water and Sewerage Investments and the Urban Mortality Decline in Sweden 1875–1930**
Jonas Helgertz, **Martin Önnerfors**
The History of the Family, 24(2019): pp. 307-338

II **Equal Expansion: Piped Water and Equality of Access in Stockholm 1878-1915**
Martin Önnerfors
Unpublished Manuscript

III **Water Access and Mortality at the Micro-Level: The Case of the Stockholm Water Network**
Thor Berger, Mounir Karadja, Erik Prawitz, **Martin Önnerfors**
Unpublished Manuscript

IV **Water Infrastructure and Neighbourhood Change : Stockholm During Industrialisation**
Martin Önnerfors
Unpublished Manuscript

Introduction

1 Motivation, aim and contribution

Life in the city is not what it used to be. Before industrialisation, urban lifespans tended to be shorter than their rural counterparts, but this started changing in the mid-nineteenth century. As industrialisation spread, it was not only the way we worked that changed, but also how we organised our responsibilities towards each other. Our health, education and poverty became a concern not only for our kin, but also for public authorities (at both national and local level) to address. Between the mid-nineteenth and mid-twentieth centuries, collecting taxes to be used for large-scale public investments gradually became a common task for the public authorities, and over time, modern welfare states developed. The period brought changes in living conditions, health and spatial organisation of cities that have affected us until today.

The spread of industrialisation and rise in public investments coincided with a decline in human mortality. And although we know that mortality declined drastically in Europe and North America during the nineteenth and twentieth centuries, there is still much we do not know about how this was accomplished. As with many questions, the answer will depend on the details of what we base our answer upon: are we analysing a whole state, a city, a neighbourhood or individuals? Are we looking across longer periods of time, or shorter intervals? Which factors are we able to take into account, and how are they best measured? Depending on the material and method we use to answer our question, the answer might be very different.

This can be illustrated by looking closer at mortality at younger ages in Stockholm, which is the city in focus for much of this dissertation. Before 1850, Stockholm was a dangerous city to be born in, and around 30% of children born would not live to see their first birthday. This started changing around the mid-nineteenth century, and by 1920, this proportion had gone down to around 5%, which is a great achievement for the city as a whole. Looking closer, however, there is more to this picture than general decline. Using an individual-level population registry for Stockholm (the Roteman archives), it is possible to measure

mortality by socio-economic status (SES). When comparing the highest and lowest social classes, white-collar vs. low- and unskilled households, a different view emerges. In 1878, the infant mortality rate of low- and unskilled households was around double of that of white-collar households (Molitoris, 2017). By 1920, this difference was still intact, despite a general decline for both groups. While this social disadvantage in mortality for the lower classes is interesting by its own right, it also leads us to further questions regarding how mortality declined. If children in white-collar households had a better chance of survival, what factors in their surroundings protected them from illness? How do these factors operate, and what determines their spread across different social groups?

Which factors that affect our health and mortality, for better or worse, change over time. In nineteenth-century cities, the disease environment was dominated by infectious diseases, to which infants and children are particularly vulnerable. Disease could spread due to lack of sanitation and clean water, and high levels of residential crowding. Social and economic factors such as income and literacy likely influenced the possibilities of choosing housing and diet, as well as hygienic practices (Preston and Haines, 1991). Periods of mortality decline have generally been characterised by improvements in access to factors protecting from disease: lack of sanitation and clean water was remedied with investments in sewerage and water networks, crowding could be eased by increased building, literacy improved with education investments, and incomes would rise with a shift towards an industrial economy. The problem with knowing how much each of these investments contributed to the decline in mortality is that they most often spread simultaneously. Furthermore, it is likely that access to these investments was not equal between social classes.

Studying the impact on society of these investments, which spread to the population in different ways, therefore requires a number of considerations. The fact that higher social classes can be expected to get access to protective factors before the lower classes makes the investigation of health and mortality outcomes especially problematic, since SES is also related to health in other ways. To complicate things further, the physical form and spread of an investment in a city has a large impact: if access to a physical amenity depends on distance to it, it will matter both where it is placed, but also to what degree social groups are spatially segregated at different scales in the city.

The question of who gets access to protective factors is an important and complicated part of studying health effects from public investments. One strand of theory predicts that higher social classes would use their advantage in resources to gain access to protective factors before lower classes (Link and Phelan, 1995; Clouston et al., 2016). This can be a problem when measuring the impact of an investment: since higher social classes can also be expected to have a better health outcomes in general, how do we know if we are measuring the real impact or the effects of an early adoption? This issue, which is often referred to as *selection into treatment*, lies at the very centre of the potential problem with using the wrong data to answer our questions. Selection is not an issue as long as we know

that, for example, higher classes are gaining access to an investment before lower classes - but this precise data is most often not available. The consequence of not being able to properly control for selection is an uncertainty of how to interpret observed effects. In the case of higher (and healthier) classes gaining access before everyone else, the consequence is often an overestimation of the health effects from a certain investment. As we will see, a general aim of this dissertation is to contribute with results where the issue of selection into access is not inherent in the data used.

This dissertation aims to add knowledge to the field of urban public investments and their consequences. By collecting and connecting data from a number of historical Swedish data sources, this dissertation aims, firstly, at showing how health and mortality was affected by public investments during the dynamic period of industrialisation in Sweden, while also taking the issue of selection into account. A second aim is to look beyond the connection between public investments and health, and study how these investments integrate in society. Specifically, the spread of an urban investment and its access outcomes will be shown. Furthermore, the external effects from changes in the urban environment due to the building on a public investment are studied.

The aim of studying health outcomes from public investments builds on a growing research field. The interest in the role of public investments in mortality decline has surged during recent years, with a particular focus on health investments such as water and sewerage systems (Cutler et al., 2006; Alsan and Goldin, 2019; Kesztenbaum and Rosenthal, 2017; Ferrie and Troesken, 2008; Troesken, 2001). The general chronology of mortality decline and its initial concentration among infant and child mortality is well known. It is still not clear how much different determinants (such as public investments) contributed to the decline. The periods of mortality decline coincided with societal changes at many levels: rising wages, improvements in education and in medical practices, and a range of sanitary improvements, to name but some changes. All of these can be theoretically linked to improved health. Among the sanitary investments, water and sewerage systems were potentially the most influential. These two systems create both a primary and secondary barrier to water-borne disease transmission. First, by preventing pathogens from entering the environment (sewerage), and second, by making it possible to stop further spread through increased personal hygiene (water) (Wagner et al., 1958). This has led researchers to argue that there were complementary effects of having both water and sewerage, but these would depend on the quality and implementation of the systems (Alsan and Goldin, 2019).

This dissertation adds valuable empirical knowledge concerning the magnitude and nature of how water and sewerage affects mortality. Exploiting a newly digitised city-level dataset of all Swedish cities where water and/or sewerage was installed from 1875 and onward, several knowledge gaps can be addressed. The data includes information on timing of not only water and sewerage investments, but also related public health investments such as food inspections and epidemic hospitals. This can help us discriminate between investments that

often have to be assumed not to overlap in their effects, even though theory might predict otherwise. Furthermore, the interaction between water and sewerage investments is analysed in detail using sequence analysis. This gives insights into the question of whether these systems complement or substitute each other, and how timing matters. Finally, since the database includes an almost full range of cities within a single national framework, the results can provide a comprehensive account of how Swedish public health investments in the cities helped bring down mortality.

To further elaborate on the health effects of access to water, this dissertation zooms in on the city of Stockholm. An important part of the work with data from Stockholm has been connecting an individual-level population registry (the Roteman archives) with a newly digitised database on water access at the building level. With these sources, it is possible to analyse the health effects of water access while also considering selection into access. Analysing water networks and mortality on a nationwide city-level as well as the individual level, this dissertation can add a multifaceted perspective to the field of mortality decline research.

The second aim of the dissertation, studying the integration and spread of public health investments in society, is addressed by focusing on the development in Stockholm. At closer inspection of these large public investments in cities, it is obvious that they are interesting to study not only when they are completed, but also during their building period. Building the water network in Stockholm, for example, started in 1861 and it was not until the earlier decades of the twentieth century that the pipe network covered the whole city. During such a long building period, there will always be those who have access and those who have not. Whether or not access to the network will distribute evenly among social classes will depend on a number of factors. First, the type of actor controlling the investment is likely to make a difference. A private actor can be expected to have higher efficiency, but less incentive to serve everyone if this is not profitable or regulated. A public actor would have an interest in giving everyone access, but only if the actor is benevolent. Second, the distribution and movement of people in the city is decisive. The degree and nature of residential segregation between social classes will determine if it is possible to discriminate against certain classes by not extending the network. In an integrated city, it is harder to keep certain groups out of access to an urban investment (Troesken, 2002).

If we want to know more about how public investments alleviate or, on the contrary, exacerbate health inequalities, we therefore need to know more about how the investing actor and socio-spatial distribution of people affect access outcomes for different groups. This dissertation aims at adding to this knowledge by exploiting a longitudinal dataset for Stockholm during industrialisation. The data is on such a level of detail regarding the public investment (water network connections) and socio-spatial composition that determinants of early access can be calculated. With this, it is possible to answer the question: were there inequalities of access to the water network in Stockholm, and what were the determinants

of getting connected earlier?

The closer inspection of public investments allows not only for investigating who gets access, but also unintended external effects in neighbourhoods where the investment is built. By adding a service such as a water network to a neighbourhood, desirability for living in the neighbourhood changes. As a consequence, it is possible that residents with a stronger economic profile, willing to pay more for access to a new amenity, drive prices and rents upwards. In turn, this can affect the ability of current and future residents to stay or move in. The process described is one where gentrification (the influx of higher-class residents) results in displacement, triggered by a change in desirability by a nearby physical change. The field of research regarding gentrification, displacement and public investments is divided, debating whether public investments actually trigger gentrification, and if gentrification triggers displacement (Zuk et al., 2018). By studying the distribution of social classes in detail before and after a public investment, as this dissertation aims to do, we can know more about the consequences that public investments might have in affected neighbourhoods.

There are two main reasons for studying public investments and neighbourhood change during industrialisation. First, the possible effects on residential segregation from public investments make them interesting from an urban historical perspective. Industrialising cities in Europe went through large shifts in socio-spatial composition, changing their patterns of how social classes segregate residentially (Kazepov, 2005). There is a clear lack of empirical evidence regarding the drivers of these changes, and how cities became segregated in the way they are today. Second, it is interesting since displacement following a public investment can result in a situation where the ones in most need of the investment might lose access to it. In the case of access to water, this could also affect health inequality in the long run. This dissertation aims to add empirical evidence to this field by answering the question: did buildings connected to the water network in Stockholm experience a shift in social composition, and what was the nature of this shift?

To conclude, the main aim of this dissertation is to study health outcomes, equality of access, and neighbourhood change aspects of urban public investments. The studies exploit a variety of city-level and individual-level data from the years 1875-1930. By covering different geographical levels, from the city to the individual, this dissertation contributes with novel empirical evidence to our knowledge of public investments in general and urban water networks in particular.

List of contribution: co-authored papers

1 Paper 1 is co-authored with one colleague (Jonas Helgertz, Lund University and University of Minnesota). The contribution to the paper of the co-author is 50 percent.

III Paper 3 is co-authored with three colleagues (Thor Berger, Mounir Karadja and Erik Prawitz). MÖ prepared data and drafted the manuscript. TB, MK, EP and MÖ designed the study, participated in data analysis/interpretation and revised the manuscript.

2 Theory and previous research

2.1 The historical mortality decline

As this dissertation focuses partly on the role of public investments for health and mortality during industrialisation, it is important to first acknowledge the development of health and mortality from a broader perspective. During the study period of this dissertation, mortality in the Western world started declining to unprecedented levels in the space of a couple of generations. In England, life expectancy at birth rose almost linearly from 40 years in 1850 to 80 years in 2000 (Deaton, 2013, p.93). In Sweden, life expectancy at birth rose from around 32 years in 1800 to 63 years in 1930 (HMD, 2020). During the same period, Sweden also experienced growing industrialisation, urbanisation and public sector involvement in the life of citizens (Schön, 2000). Questions about what in this radical societal development helped to double the lifespan in little more than a 100 years have naturally interested researchers, and still do. Despite a long research tradition on mortality decline, many of these questions still remain unanswered.

Across the Western world, the mortality declined with differences across countries. According to Riley (2005), mortality transitions in Europe began as early as the 1770:s. Up until the end of the nineteenth century, Europe was leading this development in increasing life expectancy together with the US, Canada, Australia and New Zealand. The onset of mortality decline was different between countries, both in timing and level of life expectancy at start. The decline was not uniform across the age spectrum, and generally started with declines in infant and child mortality (Corsini and Viazzo, 1997). The mortality decline has been presented as a part of demographic transition theory, which describes and predicts a society's transition from agricultural to industrial (Davis, 1945). According to Bengtsson and Ohlsson (1994), the earliest work on demographic transition was based on the Swedish experience, due the availability of reliable demographic data from early historical periods.

The Swedish mortality decline followed a number of phases. In the first phase, which is the situation before the transition starts, mortality rates are high and volatile. Mortality began to fall around the turn of the nineteenth century, and would then be in decline for the coming 140 years until reaching a lower stable state around the 1940:s (Bengtsson and Ohlsson, 1994, p.18). The Swedish mortality decline had two distinct features. First, it was primarily driven by a decline in infant and child mortality (Brändström et al., 2000a). Second, there was a considerable difference between the levels of mortality in urban and rural areas throughout the decline. These features were at large shared with other countries, but the timing and extent could vary (Fariñas and Oris, 2016; Riley, 2005; Cutler et al., 2006). The difference between urban and rural infant mortality in Sweden can be seen in Figure 1. As seen in this figure, infant mortality started declining rapidly at the turn of the nineteenth century. In 1810, when rural-urban data becomes available, we clearly see the

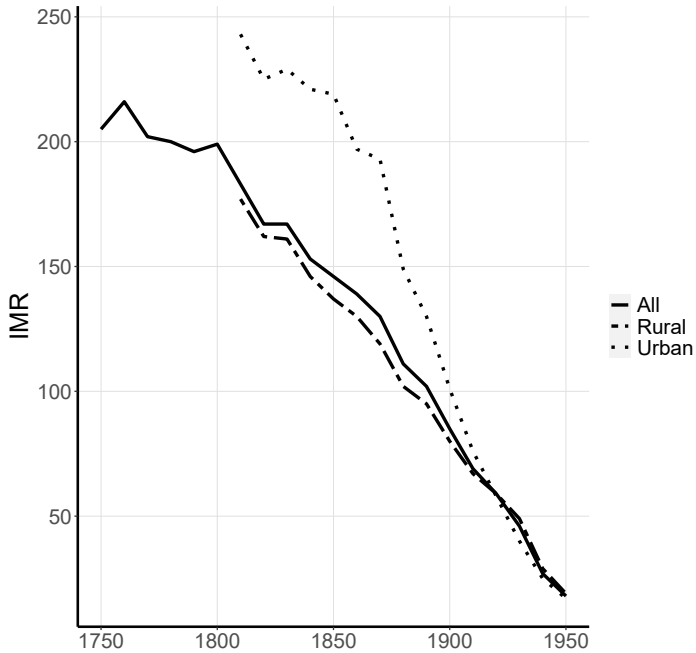


Figure 1: Infant mortality rate, Sweden. Source: SCB (1969, p.115)

so-called ”urban penalty”: in this decade, infant mortality is almost 40% higher in urban areas. It is not until 110 years later, in 1920, that this penalty no longer exists in Sweden.

There are two main questions concerning this development: what drove the decline in general, and what caused the urban penalty to disappear? The first question was answered by Thomas McKeown, who concluded that nutrition was the main cause. In his studies of England and Wales, he argued that improvements in nutrition was the key factor driving the mortality decline, and this conclusion was reached by excluding a number of other candidates (McKeown and Record, 1962). Although the authors did not entirely rule out these other factors (medical advances, declined virulence of disease and public health investments), they argued that the timing and nature of different disease-specific mortality rates fitted best with nutrition. McKeown's argument sparked a debate and has been widely criticized, but also built upon. The method of excluding factors based on their timing has been criticized as unsatisfactory, especially since McKeown could not show empirically that nutrition had actually improved (Aaby, 1992; Szreter, 1988). Fogel et al. (1978) later built on McKeown's argument by adding empirical evidence related to nutrition, by using both adult height measurements and food production outputs. Another factor mentioned by McKeown is advancement within the medical field. Examples of these advances that are commonly discussed are breastfeeding practices (Woods et al., 1988), vaccines (Mer-

cer, 2014) and antibiotics (Mackenbach et al., 1997). Further, it has been argued that the microbes carrying infectious diseases declined in their virulence, thereby lowering mortality. For the Swedish mortality decline, this has been suggested as a likely determinant by Fridlizius (1985), but only for the decline at the initial stage.

Some researchers have tried to synthesise this multitude of determinants and theories. Easterlin (1999) notes that economic growth, whether argued to bring nutrition or medical advances, can not be the main driver of mortality decline given the historical evidence. Cutler et al. (2006) acknowledge that determinants, rather than being main drivers, are important in different periods of time. They argue that economic growth and nutrition may have been important at early stages (mid-eighteenth to mid-nineteenth century), but that this is still debated. Advances in medicine, they argue, were mostly important during the post-World War II period. The period in-between, mid-nineteenth to early twentieth century, was when public health investments were the main driver of the mortality decline. We will now review the role of public investments more in detail.

Public investments and mortality decline

Concerning what public investments have done for the mortality decline, Deaton (2013, p.96) states: "the major credit for the decrease in child mortality and the resultant increase in life expectancy must go to the control of disease through public health measures". This is, as we will see, an observation that might not apply for all countries and that is in need of further empirical backing. As argued by Chapman (2019) in the case of Britain, public investments have in later years of the ongoing debate emerged as a likely very important determinant. Despite this, the empirical evidence of its magnitude is far from consistent. There are several types of public health investments discussed as possible determinants. Szreter (1988, p.11), in the case of Britain, argues that the decline in the late-nineteenth century can be interpreted as "urban congestion remedied by social intervention". Britain experienced rapid urbanisation during this century, with likely increases in population congestion as a result. According to Szreter, the steady increases in life expectancy experienced during the eighteenth century reached a standstill between 1820 and 1870 which is to be attributed to the problems of urbanisation (this has also been observed for the US by Smith (1983)). Szreter mentions a number of public investments that supposedly helped mortality to decline further: housing quality projects, local hospitals and maternity services, food and milk inspections, and water/sewerage networks. These are investments that have also been observed in the U.S (Duffy, 1992) and in Sweden (Sundin and Willner, 2007), and have been implemented in different combinations throughout Europe and North America during industrialisation.

Out of these mentioned public investments, water and sewerage networks were arguably the most ambitious and pervasive when it came to life in the city. In Sweden, public in-

vestments in network infrastructure (such as water, sewerage and communications) was a rapidly growing share of national expenses from the mid-nineteenth century and until the 1920s - at many times growing faster than the average growth of the economy as a whole (Magnusson, 2000, p.187). The implication for mortality in Sweden of these large investments is, despite their importance, still not clear.

The impacts of public health investments in water and sewerage have been studied extensively outside of Sweden, with the main share of studies coming relatively recently. Typically, a study involves one or a number of geographical units for which an outcome (a mortality measure) and a treatment (timing of water and/or sewerage) exists. Finding a specific answer regarding the role of these investments in the mortality decline does, however, present a number of caveats.

First, there is the question of study units. While many of the recent studies include a number of cities or regions[1], there is an equally large group of studies concerning only one or a few cities[2]. The studies focusing on a small number of units have often contributed with interesting angles, such as differences in access and outcomes between racial groups (Troesken, 2002) or socio-economic groups (Kesztenbaum and Rosenthal, 2017). The studies making use of larger datasets come closer to an answer concerning the contribution of these systems on a societal (national) level, which is where the mortality decline is most often discussed. No studies have, to date, presented empirical evidence on a nationwide scale.

Second, there is the important question of what kind of sanitation system is being measured. One can roughly categorise the types of systems studied into water distribution networks, sewerage removal networks, and water purification systems. Each of these systems have a separate impact on the fecal-oral route of disease transmission: the Bradley classification (as described in Bartram and Hunter (2015)) makes a distinction between water-borne and water-washed disease. Water-borne disease involves a pathogen being ingested directly via drinking water, whereas water-washed disease is transmitted between persons because of poor hygiene. Although not mutually exclusive, these categories have important implications for what can be deducted by studying different sanitation systems. A water distribution system has effects on both water-borne and water-washed disease, since it delivers water both for drinking and washing. A sewerage system, removing contaminated waste from the environment, can thereby complement a water system, but not alone solve the problem of water-borne disease. The source of water, or the quality of the water purification

[1]Including between 15 and 75 units: Alsan and Goldin (2019); Anderson et al. (2018); Beach et al. (2016a); Cain and Rotella (2001); Cutler and Miller (2005a); Floris and Staub (2019); Peltola and Saaritsa (2019); Duflo et al. (2015); Woods et al. (1988)

[2]Kesztenbaum and Rosenthal (2017); Jaadla and Puur (2016); Ferrie and Troesken (2008); Ogasawara and Matsushita (2018); Knutsson (2020); Burström et al. (2005); Burström and Öberg (2006); Macassa et al. (2006); Van Poppel and Van der Heijden (1997)

system, is crucial to the health outcome of the water distribution system. Theoretically, the combined sanitation systems could be either substitutes to each other, or complements. While it is more logical to assume that a city would be better off with both a water and a sewerage system, a water system might alone lower mortality considerably if used correctly. Consequently, more research is needed in order to say something about the magnitude of contribution of different systems individually, and how they interact (Alsan and Goldin, 2019; Duflo et al., 2015).

The empirical evidence from outside of Sweden presented regarding the contribution of public health investments, and especially water and sanitation, is growing but scattered. Many of the most influential studies have found large effects on mortality from different kinds of sanitary investments: Cutler and Miller (2005a), for example, find that water purification is behind 50% of total mortality decline, and 75% of infant mortality decline in their city sample. Alsan and Goldin (2019) find that water and sewerage systems combined account for a third of the decline in child mortality in the study area of Boston, US. Conversely, Anderson et al. (2018) find no effects of water purification on total or infant mortality in their sample of 25 US cities. From Sweden, a number of studies exist on single cities, or a smaller number of cities: (Knutsson, 2020; Castensson et al., 1988; Burström et al., 2005; Burström and Öberg, 2006; Nilsson, 1994; Edvinsson, 1992). The results generally show mortality reductions associated with the introduction of water, sewerage and/or water purification, but no unambiguous picture appears when regarding the combined results of previous research.

Revisiting the development of the Swedish mortality decline shown in Figure 1, it seems clear the the decline in infant mortality had started by the turn of the nineteenth century. To the extent that infant mortality correlates with water-borne disease mortality (which is argued by Alsan and Goldin (2019)), this early decline has consequences for how we can view the role of public investments[3]. Since the majority of Swedish water and sewerage investments were built after 1850, the initial decline must have been driven by other factors. This has been noted by Nilsson (2013), who argues that public investments could not have started the decline, but rather reinforced it and brought water-borne disease mortality to its lowest levels to date.

2.2 Socio-economic status (SES) and mortality at the micro-level

In addition to analysing the macro-level contributions of public investments to the mortality decline, it is also important to consider determinants at a more precise level. Analysis

[3]Cause-specific mortality data for Sweden exists in machine-readable format also for the period 1749-1859 on various levels of aggregation (Lundh, 2003). The cause-of-death string data has not, according to the author's knowledge, been matched and compiled and therefore, no comprehensive data on Swedish water-borne disease mortality rates exists for periods before 1850.

on an aggregate level prohibits an explanation of specific mechanisms wherein mortality is affected by variables operating at, for example, the building level or within the household.

In theory, it is hard to isolate an effect from the roll-out of a public investment without taking these micro-level variables into account. As we will see, it is not unlikely that micro-level determinants of mortality co-vary with access to a public investment, such as a water network. If this is the case, macro-level results will be confounded unless this potential selection issue is not handled properly. In many cases, having detailed data on households and individuals is the only way to be sure that what is being observed is the intended mechanism. We will therefore briefly discuss variables and theories involved in studying mortality at a more precise level.

One of the potentially most important variables affecting mortality, especially at the micro-level, is SES. This is a concept that is used in a wide variety of research contexts and it has no unifying definition. Broadly meant to capture a person's social and economic standing in society, SES is likely easiest to pin down by considering how it is usually measured. The three most common empirical dimensions along which SES is measured is financial resources, education and social class (which is often measured using occupation). A number of previous research results highlight the use and role of SES in mortality studies. In late twentieth and early twenty-first century societies, a higher SES has been found to be negatively associated with mortality and positively associated with health. Adult morality has been shown to be lower in groups with higher financial resources (Chetty et al., 2016; Elo, 2009; Smith, 1999), higher education (Elo and Preston, 1996; Hayward et al., 2015; Torssander and Erikson, 2010) and social class/higher-ranked occupation (Burström et al., 2005; Marmot et al., 1991). Although the links between SES and mortality can be considered an established fact in today's society, researchers have not agreed upon whether these links have always been there, and the empirical evidence of historical SES differences has been sporadic.

One the one hand, some researchers argue that SES differences in mortality were small or non-existent in the past (Razzell and Spence, 2006; Woods, 2004; Bengtsson and Dribe, 2011). For Sweden, recent studies have shown an emergence of an SES mortality gradient as late as 1950, using all-cause mortality data (Bengtsson et al., 2020) as well as cause-specific mortality data (Debiasi and Dribe, 2020). The latter study even shows a positive association between higher SES and mortality for men in the nineteenth and twentieth centuries, which is likely linked to health behaviour. On the other hand, a number of researchers argue that SES differences in the past were similar to today's pattern (Van Poppel et al., 2009; Blum et al., 1990; Deaton, 2016).

In recent years, one of the most notable theoretical frameworks explaining SES inequalities in health is the Fundamental Causes Theory (FCT). Presented by Link and Phelan (1995), their theory views SES as the fundamental cause of disease, and predicts that health

inequalities will not change over time. The mechanism behind this prediction is that SES can be used to gain privileged access to protective factors that enables risk avoidance. The FCT was a break with existing theory. Antonovsky (1967) had argued that health inequalities between SES groups should be narrowing over time. This argument was based on the ability to eliminate preventable deaths, and the growth of public health investments play the most important role in narrowing the gap.

The FCT was extended with a temporal view in Clouston et al. (2016). In this view, the risk of a specific cause of death can change differently across SES groups. If a health innovation (such as a new medical technology) emerges, the FCT predicts that higher-SES groups will gain access to this innovation before lower-SES groups. This would initially lead to a period of increasing health inequalities, as the ones with access to the innovation can protect themselves from disease. As the health innovation gets widely accessible, either through price or availability changes, lower-SES groups can start gaining access, and health inequalities will recede. This process is repeated for new causes of death, which means that higher-SES groups can continue to gain access first, thereby perpetuating health inequalities across time. The nature of the innovation studied dictates how this process works: as mentioned by the authors, the spread of an innovation can (in theory) be hampered by frictions, such as residential segregation.

An even more specific theoretical framework within what determines mortality and the role of SES was presented by Mosley and Chen (1984). This framework lists a number of *proximate determinants* of mortality at younger ages. Being proximate determinants, these variables are mostly observed and operating at a more detailed level, such as the household or its surroundings, which could be the building or the neighbourhood. Originally, this framework was developed for developing countries in the late twentieth century, but it has also been used to describe the disease environment in nineteenth-century cities. The authors list five categories of variables: maternal factors (mother's age, birth parity and interval), environmental contamination (water access, residential crowding, level of sanitation), nutrient deficiency, injuries, and personal illness control (hygiene practices, access to medical care). Regarding the link to SES, the authors argue that if SES is involved in determining mortality at younger ages, it must take the path through one of these groups of determinants.

A large body of research exists where specific determinants of mortality decline are investigated, spanning over several countries, historical periods, and levels of aggregation. At the city level, Woods et al. (1988, 1989) model drivers of infant mortality in UK cities during the nineteenth century. Apart from urban water systems, they also find that education, qualified midwives and declines in fertility are important drivers of mortality decline for infants. Szreter (1988) notes that the the UK mortality decline also had periods of increases in mortality, as urbanisation was intense in periods and conditions in industrial cities were detrimental. This is also shown by Jaadla and Reid (2017), who find that mining and textile

towns had considerably higher mortality at younger ages around the turn of the twentieth century, compared to rural regions.

The influential study of Preston and Haines (1991) showed a number of mechanisms regarding mortality at younger ages during American industrialisation. Analysing data from urban as well as rural areas, they find that city size and race were the most important variables explaining mortality differences. From Sweden and Scandinavian countries, a number of studies exist on drivers of mortality at younger ages. In both Sweden and Denmark, considerable heterogeneities between regions have been identified during the late nineteenth century (Brändström, 1993; Løkke, 2002). Common determinants of mortality are size of place, illegitimacy, and parental SES. Studies of specific cities have added complexity to the general patterns. Burström and Bernhardt (2001), studying Stockholm, found that SES differences emerged only after 1890, and that illegitimacy was a strong predictor of child mortality. Edvinsson (1995), studying the town of Sundsvall, found no large variations in child mortality between parts of town, which was against expectations. Sundin (1995) shows that SES differentials in infant mortality increased in times of decline in the city of Linköping during the nineteenth century.

The relation between SES and mortality at the micro-level during Western industrialisation is, in summary, a complex issue. While SES inequalities in mortality have been observed across many contexts, it has been argued that they emerged later than what has been previously thought. SES has possible correlations with a number of variables which affect mortality, and this underlines the importance of being able to empirically separate SES as far as it is possible. As we will see below, the relation between SES and access to public investments in health is complicated by political as well as spatial factors.

2.3 Urban networks and population: the interplay between social status, access and neighbourhood change

The second aim of this dissertation is to study how a public investment integrates into a city. More precisely, the aim is to view the processes determining who gets access to the investment, and also what impact the investment itself has on the housing market of which it becomes a part. To fulfil this aim, two main areas of research will be in focus. First, theories and research regarding how public actors choose to deliver services (public or private) will be reviewed, with a specific focus on industrialising cities. Second, the research field concerning the role of public investments in neighbourhood change will be addressed. Here, the focus will be specifically on how new additions to the built environment might affect the desirability of a neighbourhood, and subsequently, the ability of different SES groups to afford living there.

Provision of welfare

Theories concerning health inequality and its determinants point to a broader discussion on how society could and should intervene in our health. The road from night-watch states focusing mainly on security to the modern welfare states has been markedly different in different countries. The histories of modern welfare states are not only interesting by their own right, but also contain knowledge about how states succeeded or failed in reaching citizens of every social class. Most importantly, the history of welfare states and their investments might tell us something about what factors were involved in producing or reducing health inequalities in the past.

During the mid-nineteenth to mid-twentieth centuries, the public increased its influence on the lives of citizens, with an increase in redistributive public investments and legislation regarding health (Lindert, 2004b). As the state expanded its responsibilities, many societies were at the same time experiencing high rates of socio-economic inequality and inequality of political representation, which has been noted in Sweden (Wolke, 2015; Bengtsson et al., 2018). The increased responsibilities of the state during European industrialisation were the results of a process which began during the Enlightenment, where 'social mathematics' were seen as path to human development. According to Porter (1999), these methods from the Enlightenment together with Christian moral imperative formed what would guide European and North American state policy during the nineteenth and early twentieth centuries.

Increased redistribution of resources for state policy was, however, a controversial idea and was met with resistance, not only from richer classes. Chapman (2018) describes how political resistance to public spending in nineteenth-century Britain would come also from the lowest classes. While richer classes would be able to substitute public services with own resources, the lowest classes would have a strained budget which did not allow even slight tax increases. Another view on political support for public investment is given by Swaan (1988), who discusses how and why public investments expanded during industrialisation. It is, in his view, a shift in what constitutes a public good: governing bodies have traditionally only concerned themselves with the public good of security and defence. As industrialisation and urbanisation progressed, the growing group of urban poor were increasingly struck by disease and poverty. The negative externalities of disease and poverty that potentially affect a whole city (epidemics, crime and riots) could make the richer urban classes support public investments in fear of their own safety. In this process, health and well-being of the individual had thereby become a public good, which would make the foundation of the modern welfare state, according to Swaan. Lindert (2004a), on the other hand, focuses on three main explanations for the rise in public spending in the late nineteenth century: income, demography and democracy (p.62). Rising per capita incomes, an ageing population and expansion of suffrage are Lindert's main explanations as to why the balance shifted

towards a public willing to redistribute resources.

Although Western ideas regarding public investments originate in the same basic principle from the Enlightenment, different ideas have come to dominate across countries. Focusing on public health, Porter (1999) describes how the British welfare state during the early nineteenth century was driven by a philosophy of individual freedom and laissez-faire. This resulted in a decentralised system where local actors (such as city councils) could choose if and how to deliver welfare to citizens. Towards the end of the century, however, the British state would reassess and move towards a highly centralised system. The US had a similar point of departure as the UK, but took a different trajectory and kept its focus on local initiative, with a strong influence of Puritan moral codes. Sweden kept a relatively passive public health profile during the first half of the nineteenth century, while the latter half saw a sharp increase central governance through a number of laws. The political ideology driving public investments in Sweden during this time has been described as pragmatic, paternalistic, but also increasingly influenced by socialism (Sundin and Willner, 2007).

In the realm of providing welfare, the choice of service provision has been a controversial issue. There is an important distinction to be made between service provision and funding. There are four possible combinations, from privately funded and privately provided to publicly funded and publicly provided, with two combinations in between. The choice between these four models can vary between types of service and over time, but they have at many times been connected to separate welfare regimes. The general theoretical expectations of public versus private provision are well known: a public actor can be expected to strive for universal access in the cases where positive externalities of a service are to the collective benefit. This might come at the expense of efficiency. A private actor, on the other hand, can be expected to enhance productivity and cut costs. The focus on profitability might compromise universal access and quality, since private actors are not directly benefiting from positive externalities (Cutler and Miller, 2005b). This general expectation can be refined with specific kinds of welfare services in mind. Regarding physical health investments, such as hospitals and water networks, markets can behave differently. Whereas hospitals can be operated flexibly and the market shared between different actors, physical network markets have a tendency to become monopolies. Water markets, for example, have enormous initial investment costs, and are therefore not likely to experience competition once they are established (Krause, 2008).

Theoretical expectations on urban water markets have further specific angles. The first one is universal coverage. An unregulated private actor building a water system in a socially segregated city would have little incentive to extend the network to poorer parts of town, owing to the investment costs and the lack of incentive regarding the positive health externalities (Hassan, 1985). A public actor, on the other hand, would have this incentive and therefore be motivated to extend the network to everyone. This assumes that the public actor is benevolent and non-corrupt. From the critical geography tradition rooted in the

works of Harvey (1973), the expectation is clearly that private providers will create unequal access. Rejecting any notions that the market would solve the problem of access through equilibrium-seeking, urban space is viewed, within this critical tradition, as a disorderly product of many different interests (Smith, 2010). As argued by Gandy (2004), private interests delivering public services that arguably should be a public good (such as water) will treat the service as a marketable commodity. In today's cities in the Global South, he argues, this creates problematic inequalities since poorer areas are spatially disconnected from the rest of the city. The other side of the debate, the "commodification" school, argues that a market price on a good such as water will generate an optimal spatial spread (Winpenny, 2005).

There is also the question of capital. According to Cutler and Miller (2005b), discussing the US water market at the turn of the twentieth century, the high investment costs can make it impossible for private actors to enter the market. They argue that some form of "state or municipal finance technique" is usually required (p.3). The opposite is argued by Galiani et al. (2005), who note that private firms can access capital markets easier than public actors, which would make them better suited for investments compared to a public actor already in debt.

Previous research on the choice of public or private in different welfare regimes has shown a range of interesting outcomes. The liberal welfare regimes of the UK and the US have received the most focus from researchers. The policy employed by the UK in water investment is an example of the most thorough private-provision strategy. Hassan (1985) argues that the UK, which was one of the earliest states to officially organise its urban water supply, was motivated in part by an underlying philosophy of economic liberalism. Initially relying on privately provided and privately funded water investments, the outcome this activity in the period 1800-1840 was described by the author as a "..classic market failure" (p.544). Cities with a private provider (around 70% of cities which had a water provider) were constantly under-serving lower-SES residents and were wary of expanding the water network due to short-term economic goals. As criticism of the water situation grew, calls for municipalisation of private actors were raised in parliament, but were defeated with the help of parliamentary lobby groups representing private water interests (Porter, 1999, p.119). Eventually, acts were passed in parliament allowing cities to take over private providers, and by 1901, 90% of of all water investments were under public control (Hassan, 1985). Beach et al. (2016b) argue that the negative externalities from urbanisation and increasing congestion in the UK (manifested in increasing death rates from water-borne disease) acted as a main motivation for municipalising private water providers.

The US shows a similar story, but with some important differences. Cutler and Miller (2005b) show that the US entered a wave of municipalisation similar to the UK, although slightly delayed. The starting point was also different, since lack of funding had impeded private as well as public actors to enter the water market at large scale (in 1830, the US

had only 45 cities with a water network, of which 70% were private). In cities with a private provider, similar problems of low coverage to lower-SES residents were reported. The situation changed with financial innovations allowing cities to borrow more funds. This spurred a drive to build and municipalise, and by 1924, the US had 9850 cities with water networks of which now only 30% were private. The new funds also allowed cities to expand into previously unserved neighbourhoods.

But there is also another angle of public provision in the US. As described by Troesken (2002), the Jim Crow era[4] of enforced racial segregation constituted a clear case of a non-benevolent public actor. During this period, the expectation would clearly be that the African-American population was discriminated against by not given access to the water network - in the same manner that they were not given access to other services, for example education (Troesken, 2004, p.9). Yet the empirical results show that African-American dominated neighbourhoods were not experiencing large delays in being connected to the water network. Troesken (2002) shows that there are two main mechanisms at play: first, the fear that epidemic water-borne disease would spread to whites motivated the public actor to expand the network. Second, he argues that the most important mechanism limiting unequal access is the lack of strong residential segregation between racial groups. Since the Southern cities were less segregated on race than previously thought, Troesken argues that it would be impossible to discriminate against one group without also denying the other.

Spatial aspects of public investments: segregation and neighbourhood change

The last point, concerning socio-spatial segregation in a city, opens up for a discussion on how segregation is measured and how we might expect this segregation to behave in Western cities during industrialisation. To illustrate why socio-spatial segregation is a crucial part of understanding access inequalities (as shown above by Troesken (2002)), a hypothetical example can be made: if every building in a city consists of 50% rich and 50% poor, there is no scenario that an infrastructure network can be spread across the city which would create an *average* inequality of access between these groups. This means that socio-spatial segregation is a prerequisite for inequality of a spatially bound amenity.

Socio-spatial segregation in the nineteenth and early twentieth centuries is likely to have been different from today. Industrialisation brought changes also to urban organisation and, in the long run, fundamentally changed the socio-spatial composition of cities. The general picture of the pre-industrial European city is one of functional and social integration (Knox and Pinch, 2014). This meant that residential segregation between classes could be expected to be vertical (i.e. different floors of the same building) rather today's horizontal

[4]The Jim Crow laws regulated racial integration in several areas of society, and existed in a number of Southern states between the late nineteenth century and up until 1965.

segregation. Although early work on pre-industrial cities by Sjoberg (1960) and Vance (1971) suggest mainly a core-periphery pattern of horizontal segregation between classes, research has since added empirical support for integration between social classes (Lesger and Van Leeuwen, 2011).

The spatial scale one refers to when talking about segregation is, however, very important in these discussions. As mentioned by Lesger and Van Leeuwen (2011), most empirical research on segregation in pre-industrial cities exists at the macro- and meso-levels, which translates into analysis of larger neighbourhoods and, at best, blocks. Recently, however, more detailed historical data has emerged from US cities. Logan and Bellman (2016) use geocoded census information from nineteenth-century Philadelphia to investigate racial and socio-economic segregation at a detailed level. They note that aggregating data even at such a detailed level as the block will hide underlying spatial separation that exists in nineteenth-century cities (p.700). Using address-level data, they find that African-American-dominated streets showed considerable SES variation, which was not the case for white-dominated streets. In the case of Stockholm, only spatially aggregated data has been available in previous research to date: it is suggested by Molitoris (2017), Soderberg et al. (2003) and Hallenberg (2018) that social classes segregated to some extent on a district (meso) level. Micro-level (building) vertical segregation is suggested to exist by multiple authors (Perlinge, 2012; Gejvall, 1987; Cronström, 1986), but this has not been shown empirically.

The discussion of public investments in cities also needs to consider that they might have consequences beyond their primary intentions. Since a city and its neighbourhoods are part of building markets, physical changes create disruptions to these markets. The addition of a new service can shift the desirability to live in an area and thereby the market value of nearby buildings (Galster, 2019). In this manner, it is possible that the externalities of public investments in health infrastructure are negative in certain ways for lower social classes. Market disruptions shifting desirability can affect prices and rents, thereby also changing the prerequisites for entering or staying in a neighbourhood. Subsequently, these externalities can, in theory, lead to an increased inequality of access to the same investment that also disrupted the market. This is what Renne et al. (2016) call "the affordability paradox" of public investments: building market effects from physical investments might render lower-SES groups out of access to a public service that they are in need of, or which they were even the primary target for.

The theoretical perspectives behind access to urban public investments involves theory on migration and neighbourhood change. Neighbourhood change is a contested phenomenon. In the same manner as the theories on spatial allocation of public investments, there are opposing fields within critical geography and neoclassical economics. While the latter regards neighbourhood change as a uncontroversial process driven by preference and capital investments, the former contends that neighbourhood change is not a naturally oc-

curring process and that it can have negative consequences for lower social classes. The debate has been most vocal in research concerning two mechanisms of neighbourhood change: gentrification and displacement. Gentrification, meaning the socially upwards transformation of a neighbourhood, has received the most research attention. Coined by Glass (1964), gentrification is a well-known modern phenomenon, and has also been observed during industrialisation in Europe (Kalff, 1987) but not systematically further back in history (Smith and Williams, 2013). The neoclassical side of the debate views gentrification as a positive force of upgrading lower-class neighbourhoods (Freeman and Braconi, 2004; Hammel, 2009) and argues that existing residents are often better off by the process. The counterargument from critical geography is that gentrification is produced on a market that has been suited to simplify capital speculation (Smith, 1979). The main problem with gentrification, according to critics, is displacement. Through rising rents and prices, existing residents can be left with no choice but to relocate to another neighbourhood (Grier and Grier, 1978). Furthermore, displacement is argued to affect potential future tenants since regular migration patterns also react to changes in pricing, which Marcuse (1985) calls "exclusionary displacement". While it has been argued that gentrification is driving displacement of lower-SES residents (Hedin et al., 2012; Atkinson, 2000; Fransham, 2020; McKinnish et al., 2010), is has also been argued that out-migration of lower-SES residents observed in gentrifying areas are parts of unrelated changes in migration patterns (Freeman and Braconi, 2004).

The reason why neighbourhood change is important when discussing public investments and health inequality is that it can alter the prerequisites of access. Previous research on this topic mostly concerns the late twentieth century and onwards, and the results give a mixed impression. Networked transport infrastructure has been frequently suggested as potentially induce gentrification (Kahn, 2007; Zheng and Kahn, 2013; Bardaka et al., 2018), which is arguably linked to displacement. Measuring displacements using evictions, Delmelle et al. (2020) find no evidence of displacement from public transport investments. Also, Padeiro et al. (2019) argue in their review of the field that many of the results on public investments can be biased by local contexts such as the built environment and local urban policy. Previous research regarding public health investments in particular is scarce, and especially during industrialisation.

In summary of this theoretical chapter, there are a few expectations that can be noted. Returning to the first aim, concerning health and mortality, two main points are of interest. First, in research on determinants of mortality decline, public investments have in recent years become a common explanation. Water and sewerage systems have, in particular, been shown to have large effects on both adult and infant mortality. Most studies to date have concerned larger cities in Europe and North America. For a study of the effect of water and sewerage systems in the Swedish mortality decline, this would at first glance translate into an expectation of similarly large results. A few things might, however, complicate this

expectation. Swedish cities were, measured in population size, small compared to cities used in previous research. Also, the Swedish mortality decline started relatively early in comparison, and well in advance of the introduction of water and sewerage systems. These two aspects could mean that lower magnitudes of results might be expected from a study of Swedish cities. Second, regarding mortality effects from public investments at the micro-level, the expectations are less clear. The Fundamental Cause Theory predicts that access to protective factors can be dependent on SES, but in the case of a networked investment, residential segregation makes this mechanism more complicated. As follows from the expectations from the second aim (below), the situation with regards to vertical SES segregation and neighbourhood change is hard to predict regarding industrialising Stockholm. This further highlights the need for detailed analysis, as these possible sources of selection are unknown. No previous research has yet investigated the impact of access to a water system using precise data, which makes the possible SES bias hard to make expectations of.

Regarding the second aim, which concerns the provision of public investments and access outcomes, there are a number of expectations to take into account. Access outcomes of public investments that have a spatial dimension are dependent on the form of organisation as well as the socio-spatial distribution of recipients in the city where it is built. While some theorists predict that private provision will be more efficient and thereby reach full coverage, a number of researchers oppose this and argue that private providers will create access inequalities, since they lack incentive to provide for lower-SES groups if this is not profitable. Furthermore, socio-spatial distribution sets the limits as to how unequal access can be, since residential segregation is needed in order for inequalities to arise. In the case of the Stockholm water system, a public provider with a clear intention of universal access (more on this below) was in charge. This would lead one to expect a more equal access outcome between SES groups. The situation regarding socio-spatial distribution in the city is, however, not clear. While some researchers have suggested that SES groups were segregated at aggregated levels (such as districts or wards), nothing is known about SES composition at the building level, which is especially important in the case of a water network. Taken together, this makes it hard to make expectations regarding access outcomes for Stockholm's water network roll-out.

Shifting the focus to external effects, theory would predict that the addition of a desirable amenity in a neighbourhood will increase the desirability to live there. This shift in desirability can manifest as higher prices or rents, which can in turn lead to displacement of lower-SES groups who can no longer afford to stay or move in. The mechanisms behind displacement can be linked to gentrification, which is a process that some researchers suggest can be triggered by public investments. Measuring gentrification and displacement is notoriously difficult, since migration intentions are seldom captured. In the case of the Stockholm water network, one would expect that connected buildings and neighbourhoods experience a shift in desirability, which makes it possible that neighbourhood change

in form of gentrification can occur. On the other hand, little is known about gentrification in an industrialising city, which makes the expectation unclear.

3 The context: urban growth, water infrastructure and health in Sweden

3.1 Swedish urbanisation

The period studied in this dissertation (mid-nineteenth to mid-twentieth century) was a period of groundbreaking societal changes in Sweden. Parallel with the movement of industrialisation went the processes of urbanisation and the increasing public sector influence over the lives of citizens. By the mid-twentieth century, Sweden had evolved from an agriculturally based economy to an economy dominated by industry and services, where the majority of citizens now lived in urban areas. The economic development of Sweden during the nineteenth century was the start of a long transition. In 1850, around 70% of the workforce was employed in agriculture, with around 15% each in industry and services. From this point on, industry and service would keep paces replacing agriculture, growing their shares linearly. By 1940, agriculture's share of the workforce was down to 30%, with industry and services at around 35% each (Schön, 2000). The starting point for this industrial transformation was not a static agricultural economy, but one that had experienced large recent shifts. The agrarian revolution, involving land redistribution and increased commercialisation of farm produce, had changed the dynamics of farming (Magnusson, 2000). With this, the agricultural economy shifted towards higher productivity and larger farm units.

The early industrialisation process (first half of the nineteenth century) occurred without large shifts in industrial technology. Apart from increases in home-based production of goods, large parts of this proto-industry was connected to agriculture and forestry, and thereby also more rural than urban (Schön, 2000). The Second Industrial revolution starting at the end of the nineteenth century, with the advent of electricity and new modes of transport, accelerated growth further. Measured as regional growth, it has been shown that the development in the period from 1890 and onwards was remarkably equal across the country (Henning et al., 2011). The authors speculate that this equal growth might be explained by the fact that the Swedish economy was export-oriented, and that the rapid expansion of infrastructure and electricity allowed also remote regions to take part in foreign markets.

Population-wise, however, the development was shifting towards the urban and long-distance migration was on the increase. As mechanisation and factories became a larger part of the economy, demand for industrial workers surged, and this demand was most often found

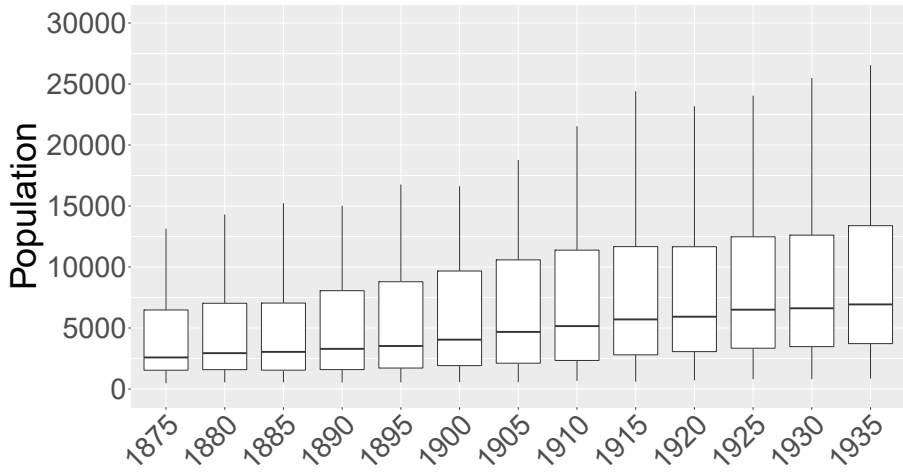


Figure 2: City size, Sweden. Source: SCB (1851)

in the cities (Magnusson, 2000). Together with this demand grew the demand for service workers, which was also an urban-dominated sector. In all, migrations during the period 1850-1920 was characterised by increasing migration distances and a focus towards places of industrial expansion, which were more likely to be urban (Lundh, 2006). These changes brought a period of increasing urbanisation to Sweden. In 1850, around 10% of the population were living in cities. In 1900, this figure had more than doubled (21%), and in 1950, almost half (46%) of the population was urban (SCB, 1969). The development was not entirely linear, and periods of slower urban growth was observed between 1880 and 1920 (Nilsson, 1989, p.306). While the growth of urbanisation is not unique to Sweden, two main features stand out in the history of Swedish urbanisation and its system of cities. First, the size of cities is comparatively small. The distribution of city sizes in Sweden over time can be seen in Figure 2. The upper and lower edges of the box represent the 25th and 75th percentiles of the size distribution of cities, and the end of the upper and lower lines (whiskers) represent the maximum and minimum values for a given year. In 1875 (the first year when city-level data is available), the median city size (the middle bar of the box) was around 2000 inhabitants, and grew to around 5000 inhabitants in 1930. Compared to the median city size in England and Wales in 1921 (92.000), the size is notably small (ONS, 1921).

Partly, this is due to the definition of what constitutes an urban area. The cities included in the city panel used in this dissertation are officially denoted cities, which is a definition decided by the state. Up until 1965, city status was not based on population size or density, but was an administrative decision. In any case, it is clear that the Swedish city system during this period was dominated by comparatively small cities. As shown in Figure 3,

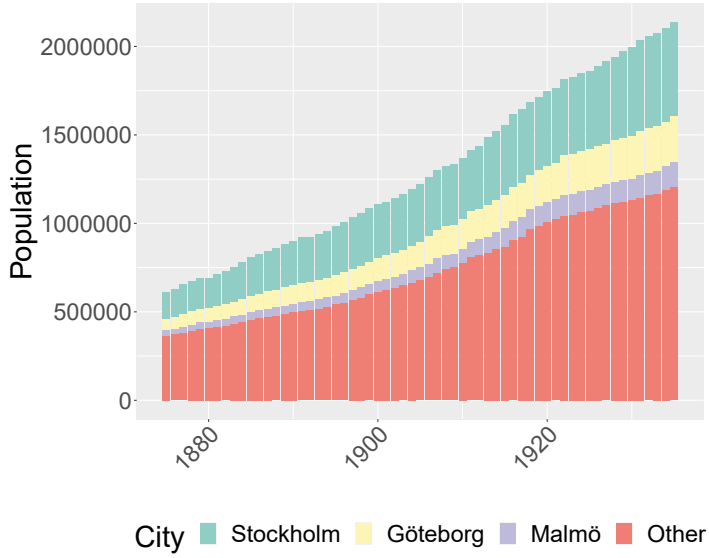


Figure 3: Urban population, Sweden. Source: SCB (1851)

there is a second feature that stands out in the Swedish city system: the dominant position of its capital Stockholm.

The figure shows the urban population size in Sweden over time, divided into the three largest cities with the remaining population grouped into one. During the period we see the rapid growth of urban population in Sweden, and throughout the whole period, Stockholm keeps between 25 and 30% of this share, and passes half a million inhabitants in 1930. The combined size of the two biggest cities apart from Stockholm does not exceed 20% during the period. Measured as a part of the whole Swedish population, Stockholm reached almost 10% in 1935 (SCB, 1969). The rapid growth and relative size of Stockholm during the study period put pressure on city authorities to intervene against the negative effects of congestion. This will be discussed further below, in the section "Stockholm".

The rapid growth of both population and the economy coincided with the growth of the public as a societal actor. Inspired by the German forerunners in social policy, the debate in Sweden on such policies was vivid in the late nineteenth century. The idea that the state should intervene beyond the night-watch state was politically controversial and was met by resistance from Swedish conservatives. The most pressing issue in the growing industrial economy, judging by what was discussed in the press, was worker's rights, followed by issues related to health and morality of the population: sobriety, health, housing and poor relief (Hort, 2014). The political discussions materialised in public spending. Financial statistics show that infrastructure (of which water, sewerage and sanitation was a large share) was around 40% of urban public spending during the last quarter of the nineteenth century.

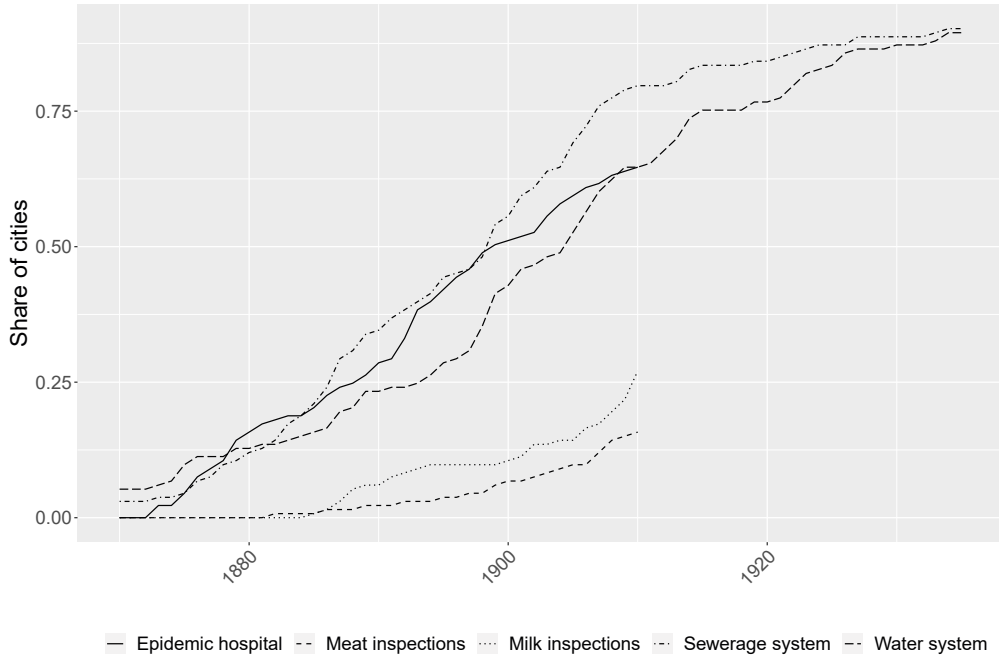


Figure 4: Urban public investments, Sweden. Source: SCB (1851)

After the turn of the century, the infrastructure spending rose to around 50% (for the period 1900-1915) (Nilsson, 2013, p.96).

Together with funding, public control was exercised through new legislations. Starting in 1868, five city statutes were released which regulated the city authorities' responsibility to supervise order (1868), fire risk (1874), building safety (1874), health (1874) and city planning (1907). The health statute of 1874 was of particular importance to the everyday life of urban citizens. This statute demanded that cities create a health council to meet weekly, and that this council implements measures to remove insanitary elements from the cities. The legislation concerned both physical investments (water, sewerage, epidemic hospitals) and inspections of commercial activity, mainly within food production. Swedish cities entered a period of intense activity to live up to the law. Total expenses in urban health-related activities tripled between 1880 and 1910 (Edvinsson, 2015). As seen in Figure 4, the share of Swedish cities building a water and/or a sewerage system increases linearly during the period, reaching almost complete coverage by 1930. Other related investments (reported in official statistics up until 1910) also see an increase, especially the building of epidemic hospitals, reaching around 65% of cities in 1910. Food inspections of meat and milk are less common but still reach a portion of cities.

Another important piece of legislation for this increased agency of local public actors in

nineteenth-century Sweden was the municipal reform of 1862. With this legislation, the old system of parish councils (integrated with the church) as decision-making units was phased out and replaced with a secular local government system (municipalities). This political reform had been debated for many years, and its proponents argued that it would help foster the people in democratic thinking. A strong motivation behind the debated reforms becoming law was likely the European wave of political uprisings in 1848, which also spread to Stockholm and resulted in riots in the city (Lindberg, 1980, p.27).

The new law created three administrative types of municipalities: cities, market towns and rural municipalities. In cities, parish councils were replaced with city councils. City council representatives were to be elected from male adults (minimum 25 years of age) who were also eligible to vote. In theory, the council members should represent all groups of citizens. In practice, however, the council came to consist mainly of nobility, burghers and a large share of businessmen, since the voting system was graded on income. Although not representative for the whole population, the city council can still be argued to be more democratic due to their larger size (100 persons) and diversity, compared to the small parish councils, which were elected internally by a small number of elder burghers (Lindberg, 1980, p.67).

The most important change that the new legislation brought was municipal financial independence. A number of changes made cities more free to choose their own course: first, cities no longer had to apply for funds from the state. The previous order involved applications which (in the case of Stockholm) required royal approval (Lindberg, 1980, p.49). Second, the new law made it possible for municipalities to directly tax their residents. Together with fees that were collected for use of public investments, municipal taxes made up approximately 60% of municipal income in late nineteenth century Sweden (Nilsson, 2013, p.142). The new legislation did, in effect, separate the state and the cities when it came to urban decision-making and finance, and was likely a necessary prerequisite for the large wave of public investment that followed.

3.2 Stockholm

Stockholm was, during the study period, the only Swedish city by international comparison of population size. It was by far the largest in the nation population-wise, and its share grew over time, as shown in Figure 3.

Economic development has coincided with periods of population growth in Stockholm. Further back in history,the city had a prominent economic position during the seventeenth and early eighteenth century, but entered a period of slow growth from the mid-eighteenth century (Wolke, 2015). In line with the European economy with which it was connected, Stockholm felt the effects of inflation, declines in real wages and surging prices of agricultural products (Soderberg et al., 2003). During the second half of the nineteenth century,

Stockholm was growing economically again, and much of this was growth in the industrial sector, and subsequently also within services. The corresponding population movements are clear: between 1770 and 1820 the population increased only by 8%, which can be compared to the growth between 1870 and 1920 (214%). Much of the population increase in Stockholm came from rural-urban migration. In general, internal migration in Sweden was high during the nineteenth century, but it was increasing both in volume and distance towards the end of the century (Brändström et al., 2000b).

New citizens in Stockholm found a city that was crowded and unhealthy. Periods of rapid in-migration were coupled with a building market that was going through swings of boom and bust during the last half of the nineteenth century. There was also a poor matching of supply and demand. As builders were focusing on building rental property for a richer clientele, the bulk of the demand was for affordable housing (Perlinge, 2012). Especially during the economic upturns of the 1870s, which saw large increases in in-migration for work, grave housing shortages for the working classes were common (Lindberg, 1980). In 1900, it was reported that 49% of one-room apartments in the city were overcrowded (defined as having more than three inhabitants). Also, the market was dominated by rental housing rather than owner-occupancy: statistics show that only 3,5% of the population were living in an owner-occupied apartment in 1905 (SSS, 1907). The market was unregulated, and it was not until the 1930:s that state authorities started issuing laws regulating the building market (Hedman, 2008). The end result was a volatile market for both building owners and residents for much of the study period.

The health situation for many of Stockholm's citizens at the mid-nineteenth century was alarming. A contemporary report noted that during the decades around 1850, there was only one European city with a worse crude mortality rate than Stockholm (Florence), and this was only for a brief period (Wretlind, 1866). The report also notes differences in mortality between city districts, something which was still present in the city in an updated report a decade later (SSS, 1897). Measured as child mortality, the differences between working class and white-collar workers were 3:1 in the 1880:s (Burström et al., 1999).

The city's socio-spatial composition went through large changes during the period. A number of factors, such as the building of category housing and increases in urban investments, gradually changed Stockholm into a more socially segregated city on several geographical levels (Gejvall, 1987). The development can be seen in Figures 5 and 6, which depict the block-level social status at the start and end of the study period, 1878 and 1920. The maps cover the northern part of Stockholm, each point represents a block and the size of the point represents the block population.

As seen in these figures, there are (in 1878) some clusters of working-class dominated blocks in the west (at Kungsholmen) and in the north, while the inner city is less densely populated and has higher shares of white-collar households. In 1920, the picture is markedly different:

Figure 5: Block-level white-collar share, 1878

to the east, the district of Östermalm has expanded and become a white-collar dominated area, while the peripheries in the west and north have been populated with large blocks with a lower white-collar share. The inner city is now almost empty of residential blocks. These figures mirror the development from vertical (on different floors of the same building) to horizontal (in different parts of town) segregation between classes that was a feature of a number of industrialising cities at the time (Kazepov, 2005).

The number of issues to deal with in the growing city was high on the political agenda and this was apparent in descriptions of debates in the city council. During most of the study period, political representation in the city was very unequal, since voting rights were conditioned on income (Wolke, 2015). In the case of the water system, wealthier citizens appointed in the council would oppose publicly funded projects (Lindberg, 1980). Despite the debates and inequality or representation, many projects were funded and started during the nineteenth century. The municipal reform of 1862 gave the city complete autonomy over its internal policy. Several areas of public investment were addressed during the last decades of the nineteenth century: sanitation (water and sewerage networks), building of hospitals, street-lights and poor relief (Råberg, 1976). The building of network infrastructure such as water networks, but also gas and electricity, was 12% of city expenses in 1870, 10% in 1880, and had risen to 25% in 1890 (Lindberg, 1980, p.513).

As will be discussed further below, the two studies on Stockholm are specifically concentrated to the district of Södermalm. While the reason behind this choice was primarily data

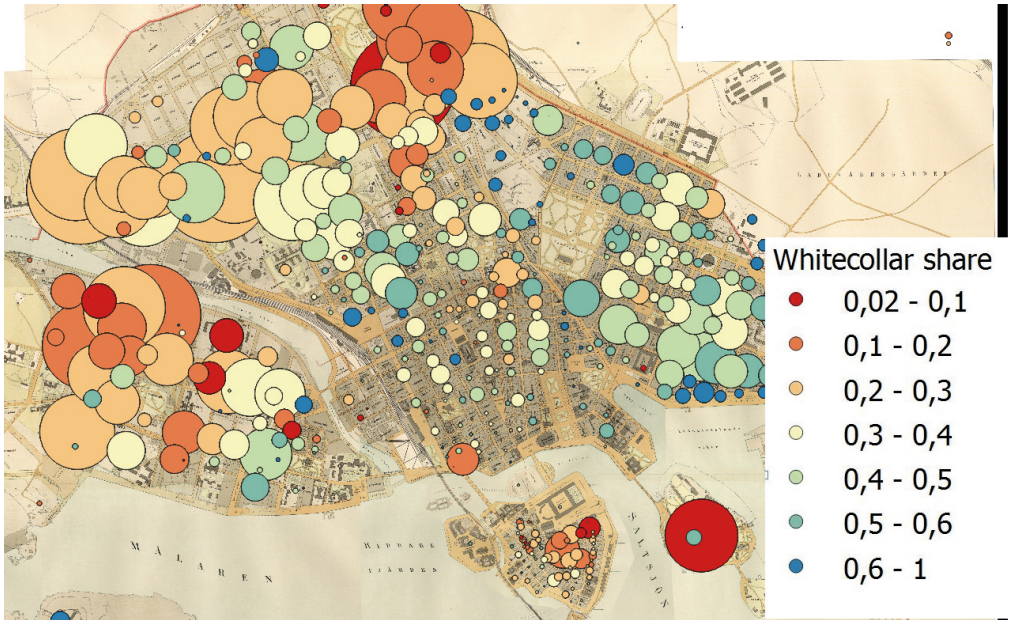


Figure 6: Block-level white-collar share, 1920

availability, it turns out that Södermalm is a suitable district for studies of consequences and mechanisms of public investments. During the study period, Södermalm held roughly one third of Stockholm's population, which makes it a sizeable part of a growing city. In comparison to other districts of the city, Södermalm has been referred to as a poor part of town (Bernhardt, 1995; Molitoris, 2015). Within Södermalm, the distribution of social classes during the study period has been described as a centre with smaller, more influential areas surrounded by poorer areas (Wolke, 2015). However, as the more detailed studies of this dissertation will show, social classes at the time did not segregate between neighbourhoods as much as between floors in the same building. This vertical segregation pattern has potential consequences for how spatial processes, such as the spread of a public investment, operate.

Regarding the public investment studied in this dissertation (the water network roll-out), Södermalm turns out to be a suitable place of study. Compared to the higher-SES areas to the north in the city, Södermalm was not as far gone in its roll-out of the network when the demographic data used in this dissertation (Roteman archives) become available in 1878. This means that there was still a considerable amount of variation and roll-out left to study as demographic data was made available. Furthermore, the mortality situation in parts of Södermalm was often highlighted as especially troublesome by contemporary authors (Grähs, 1875; Wretlind, 1866). Studying the high-mortality areas of the city can be an advantage, since any investment that has a theoretically negative effect on mortality

should be at its most pronounced in these areas.

4 Data and Methods

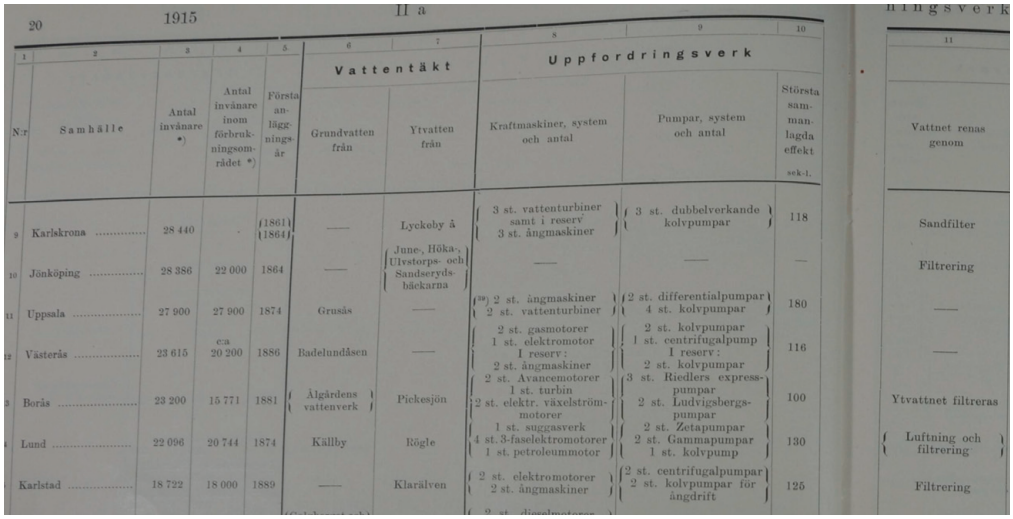
The use of new digitisations and combinations of data sources is one of the main strengths of this dissertation. The data used comes from three main sources, and focuses on the late nineteenth/early twentieth century.

4.1 Panel of Swedish cities

The data used for the first study comes from a number of combined sources of official statistics on the city level. The Swedish official statistics authority was established in 1748 as the first in the world. City-level data is known to exist even from the eighteenth century, but not in printed form (Nilsson, 1989). For the period of interest, demographic data comes from the main statistical reports (SCB, 1851, 1861, 1911a,b). The mortality data of interest, which is cause-specific and on the city level, exists from 1875. A database on water and sewerage investments, along with other public investments in cities, has been combined from 1875 and onwards from the sources SKF (1904) and Lindman (1911). An example of detailed data on water provision can be seen in Figure 7. For each city and year, specific information on sanitation infrastructure and water source is present and updated on changes. All demographic and public investment data has been digitised to machine-readable format as part of a larger project where the first paper in this dissertation is included.

The combination of datasets from different sources depended on city names. These were, for the most part, trivial string matches apart from those containing older spellings - which were matched using approximate string matching. A further matching issue was the cause-specific mortality data, which was available in string format, often times in older Swedish spellings. These causes of death needed to be coded into categories of water-borne and airborne disease for use calculating mortality rates. Apart from differences in spelling, diseases have sometimes also changed names over time. With a starting point in the classification work by Molitoris (2017), which was kindly shared, and the linking information from DDSS (2020), causes of death were inserted in a database scheme and matched using approximate string matching.

The yearly health board reports from Lindman (1911) offer a control to the tabular data, with a detailed report on health and sanitation in each city. The two sources correspond very well, which corroborates the reliability of the investment timing used in analysis. The total number of cities present in the final dataset is 114. Since a number of cities invested in sanitation before the start of mortality data publication (1875), 84 cities are included in



20	1915				II a						
1	2	3	4	5	6	7	8	9	10		11
					Vattentäkt		Uppfordringsverk				
N:r	Samhälle	Antal invånare *)	Antal invånare inom förbrukningsområdet *)	Första anläggningsår	Grundvatten från	Ytvatten från	Kraftmaskiner, system och antal	Pumpar, system och antal	Största sammanlagda effekt sek.-l.		Vattnet renas genom
9	Karlskrona	28 440	-	(1861) (1864)	—	Lyckeby å	3 st. vattenturbiner samt i reserv 3 st. ångmaskiner	3 st. dubbelverkande kolvpumpar	118		Sandfilter
10	Jönköping	28 386	22 000	1864	—	Junc-, Höka-, Ulvstorps- och Sandseryds-bäckarna	—	—	—		Filtrering
11	Uppsala	27 900	27 900	1874	Grusås	—	(**) 2 st. ångmaskiner 2 st. vattenturbiner	2 st. differentialpumpar 4 st. kolvpumpar	180		—
12	Västerås	23 615	c:a 20 200	1886	Badelundåsen	—	2 st. gasmotorer 1 st. elektromotor I reserv: 2 st. ångmaskiner	2 st. kolvpumpar 1 st. centrifugalpump I reserv: 2 st. kolvpumpar	116		—
3	Borås	23 200	15 771	1881	Ålgårdens vattenverk	Pickesjön	2 st. Avancemotorer 1 st. turbin 2 st. elektr. växelströmmotorer	3 st. Riedlers expresspumpar 2 st. Ludvigsbergspumpar	100		Ytvattnet filtreras
4	Lund	22 096	20 744	1874	Källby	Rögle	1 st. suggasverk 4 st. 3-faselektromotorer 1 st. petroleummotor	2 st. Zetapumpar 2 st. Gammapumpar 1 st. kolvpump	130		Luftning och filtrering
5	Karlstad	18 722	18 000	1889	—	Klarälven	2 st. elektromotorer 2 st. ångmaskiner	2 st. centrifugalpumpar 2 st. kolvpumpar för ångdrift	125		Filtrering

Figure 7: City-level water and sewerage data. Source: SKF (1904)

the final panel.

4.2 The Roteman archives

The studies focusing on Stockholm make use of two large-scale micro-level datasets which are, considering the historical period they cover, unique in their precision and size. The first one is the Roteman archives, which is a database distributed as part of the SwedPop project. The SwedPop project aims to harmonise and distribute Swedish historical data at the micro-level (swedpop.se). The Roteman archives are the longitudinal population records that were kept for the city of Stockholm between 1878 and 1926. The archives were established to help manage expanding services in a fast-growing city. In 1877, the city council created a population and tax board (Mantalsnämnden) which were to appoint registrars to keep track of the city's newly created 16 wards (Geschwind and Fogelvik, 2000). The rapidly increasing population in the city during the second half of the nineteenth century was too much for the original bookkeeper (the church) to keep up with, especially since intra-urban migration also was on the rise. The ward registrar (Swedish: roteman) kept track of demographic events in his ward, such as births, deaths and migrations, but also collected information on occupations (updated with the yearly census), civil status, smallpox vaccination, and information concerning poverty. As the city grew, the ward structure changed and expanded, from 16 wards in 1878 to 36 in 1926 when the system was disbanded. The Roteman archives have been digitised by the Stockholm City Archives. Over the course of more than 20 years, 6.3 million records have been made machine-readable, and the archives contain roughly 1.8 million individuals.

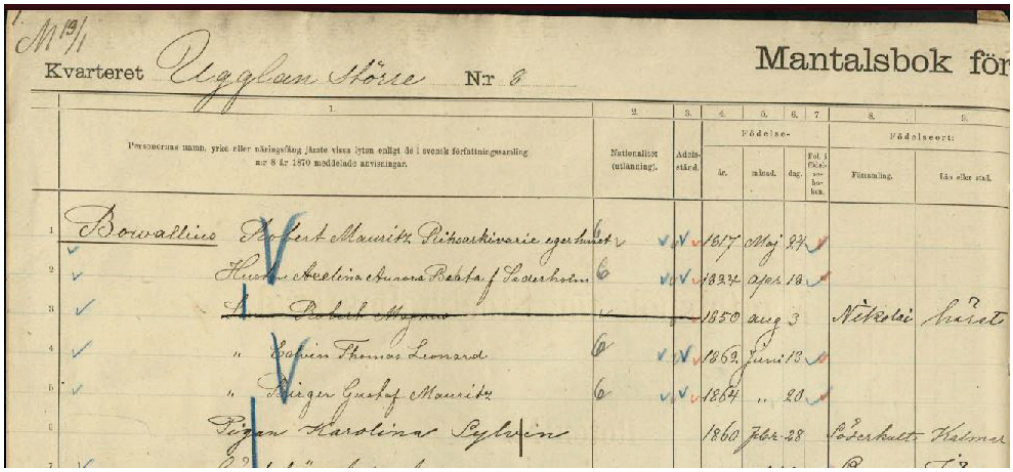


Figure 8: A ledger from the Roteman archives

The Roteman archives organised individuals according to their property of residence. For each property, a ledger was kept by the registrar, and as people appeared and disappeared in the property, they were added or crossed out in the ledger. Most often, the property that a ledger covers consisted of one or a small group of connected buildings. An example of such a ledger can be seen in Figure 8.

The fact that the data structure centres around the property makes the Roteman archives especially suitable for exploiting the spatial dimension. Prior to this dissertation project, geocoded information existed at the block level (which is an aggregate of buildings, and thereby, of ledgers) and had not been exploited for spatial analysis. As a part of this dissertation, several geographical additions have been made. First, all buildings in the Södermalm district of Stockholm have been geocoded. The result of this can be seen in Figure 9 and in detail in Figure 10. In these figures, every green circle marks the coordinate of a building, which is linked to the Roteman archive ledgers.

Linking ledgers to the spatial dimension means that they also have to be linked in time. Since the archives span across almost 50 years, there are a large numbers of changes taking place both administratively by the ward registrars, and also changes in buildings and addresses. For the analysis of this dissertation, a number of data issues needed to be solved. First, the relation between building and ledger can change over time. The obvious problem with volatile ledger data is that there is no persistent unit over time that connects inhabitants to the same building, even if the building name or number has changed. Without such a unit, the analysis of a building over time would be impossible. Furthermore, since the linking of data sometimes uses the address level, which is also subject to change, linkages need to be made on the correct version of streetname and housenumber, and the linkage must cascade forward in time. The data structure of the Roteman archives makes the link-

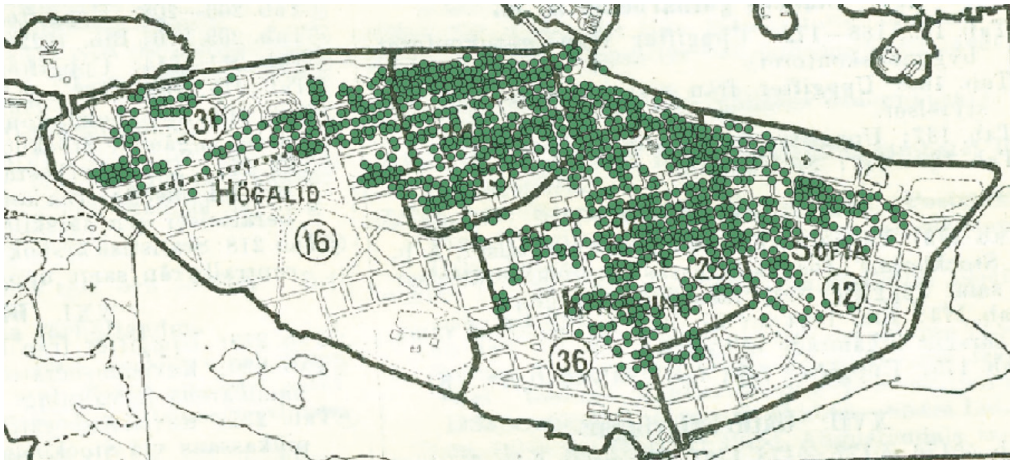


Figure 9: Geocoded buildings, Södermalm

age of ledgers difficult: if two ledgers are merged into one, this is noted only at one point in time in the database, and there is no identifiers in place to know how future ledgers connect backwards. The solution to these inherent problems is to identify the smallest set of blocknumbers and addresses that exist within a ledger. This was accomplished using network analysis using a Python package by Hagberg et al. (2008), with which all ledgers ever related to each other were modelled in a graph structure. From this graph, composite and time-constant ledger ID:s were extracted. Creating these time-constant units without a graph structure would have required walking through the chronology of each of the over 50.000 Roteman ledgers individually, which would not have been feasible in the time frame of this dissertation.

The second important data source used for the Stockholm part of this dissertation is a database on water connections. Since water tax was collected and service lines installed, data existed on the exact roll-out of the water network from the beginning of the Roteman archives in 1878. Unfortunately, a portion of the water network expansion has already happened when the Roteman archives start, since the network building start was in 1861. How big this portion was, measured in persons with access, was impossible to know beforehand, since the data had not yet been fully digitised or linked.

One part of the database was already digitised when this dissertation started, by Petersson (2005). This database contains new water connections on the block and building level for Södermalm between 1875-1915, but it had not yet been linked to demographic data. To this database, a baseline of connections was needed (since only new additions were present), and this was located at the Stockholm City Archives and digitised as a part of this dissertation. The data consists of a water tax registry at the building level, and an example can be seen in Figure 11. The data shows an address and the number of rooms paid for.

Figure 10: Geocoded buildings, Södermalm

The digitised water data was linked to the Roteman archives using all available information. Water connections and taxes that did not match directly on blockname and blocknumber were processed with string matching algorithms to find possible matches. Further remaining unmatched units were tried using matching on address, which exists in the Roteman archives as a part of each ledger. On the Roteman side of the linkage, 71% of all blocknumbers ever inhabitated appear sometime in the digitised water data. Measured in population, around 85% (average for all years) of Södermalm's population live in buildings where water data exists. The remaining buildings (not present in water data) are likely not present since they received water after the study period ended. On the water data side of the join, a portion of connection data remained unmatched. The unmatched water connection data are rows where data is insufficient, which most often means that it only consists of a block name or a streetname, or even less. By ocular inspection, these non-matches appear to be water connections and taxes belonging to companies (since companies were taxed differently than residential buildings).

Using the Roteman archives for analysis of socio-economic differences is possible with the

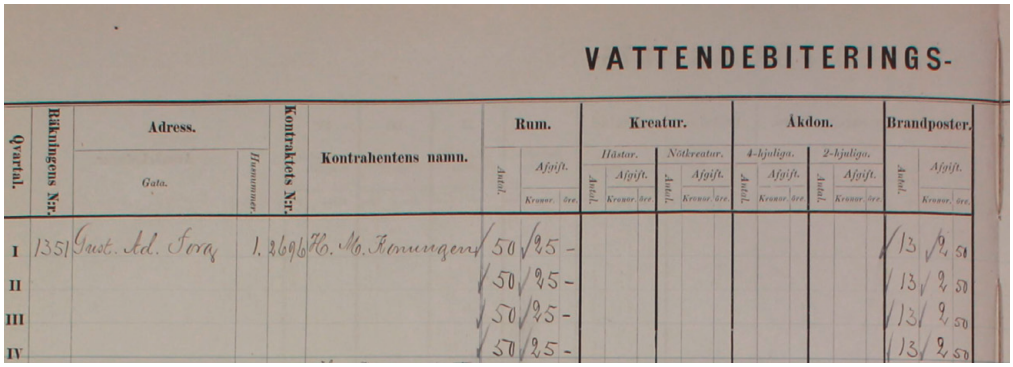


Figure 11: Example of water tax data

use of occupation titles. These titles have been linked to the Historical International Standard of Classification of Occupations (HISCO) system (Van Leeuwen et al., 2002) using direct and approximate string matching. With a linked HISCO to a title, the HISCLASS classification of historical SES can be used (Van Leeuwen and Maas, 2011). The HISCLASS scheme divides occupations based on their character in order to derive the societal position of an individual. Occupations are categorised according to level of skill, if they are manual or non-manual, economic sector, and whether or not is it a supervisory position. HISCLASS consists of 12 categories of workers, which have been organised into three larger groups: white-collar/non-manual workers (HISCLASS 1–5), skilled manual workers (HISCLASS 6-8), and low-skilled/unskilled manual workers (HISCLASS 9-12). The HISCLASS scheme fits well together with the Roteman database, since it was developed specifically for occupations from the nineteenth and early twentieth century.

For the purposes of the second and fourth study in this dissertation, HISCLASS has been used to reflect socio-spatial composition on different levels of aggregation. To do this, focus has been put on the household head (which is always denoted in the Roteman archives) and the building. The socio-spatial composition of a building is operationalised by computing the share of household heads, by HISCLASS group, residing in a building at a certain point in time.

Although the information in the Roteman archives is well suited to study issues related to population dynamics, it is not without problems. One issue is that within-ward migrations might be underreported. Every individual was obliged to report to the ward registrar when migrating outside of the ward, but this was not mandatory for within-ward migrations (Geschwind and Fogelvik, 2000). Despite this, a large number of within-ward migrations are reported in the archives, but the extent to which they are underreported is unknown.

4.3 Methods

Negative binomial count regression

The first study, based on a city-level panel with detailed mortality data, estimates the effect of water infrastructure on mortality using a negative binomial count estimator. The reason why this was chosen over a regular OLS estimator was the fact that a large number of city-years had zero deaths. Furthermore, the distribution of the outcome variable is overdispersed, which means that the conditional variance of the outcome variable is larger than its mean. In the presence of zero-inflation and overdispersion, a Maximum Likelihood estimator with a with a negative binomial distribution is best suited (Allison, 2009). The coefficients from such an estimator can be presented as Incident Rate Ratios, which denotes the relative risk of an event occurring, where 1 equals no effect.

Cox regression

The second study investigates time-to-connection of buildings, aiming to investigate if there was a social gradient that manifested as a delay for certain types of buildings. To this extent, a Cox proportional hazards model was used. While Cox regression is often used in studies of mortality, it is suitable for any types of estimation where time to a certain event is of interest. In contrast to other common estimators, such as OLS, a Cox proportional hazards estimator can handle a panel dataset where changes occur in different variables at different points of time, and keep track of how much time is spent in different states for each individual. In this manner, a Cox model is especially well suited for studies of detailed individual panels if the research question involves an interest in time to an event. The third study also makes use of a Cox proportional hazards estimator in order to estimate mortality at the individual level. This type of estimator is suitable in mortality studies, where time at risk of death needs to be properly taken into account. Individuals are considered at risk when migrating to the study area, and are from time of entry contributing with data regarding all included covariates. Likewise, individuals are considered censored upon leaving the study area. In a general form, the Cox regression equation can be expressed as:

$$\log(h(t)) = h_0(t) \exp\left(b_1 x_1 + b_2 x_2 + ... + b_i x_i\right)$$

Where $h_0(t)$ denotes the baseline hazard (which remains when all explanatory variables are set to zero), and the exponentiated combination of the explanatory variables (Allison, 2014). The hazard h at time t is the product of these two functions. The results are expressed as hazard ratios where 1 is interpreted as no increase or decrease in the hazard compared to the reference category. Since the data used in the analysis is yearly, it can be viewed as a

discrete-time dataset. In cases with frequent intervals, the ties created can create interval bias. An alternative is therefore to apply a GLM log-log model as suggested by Broström (2018), which is the method applied as a sensitivity analysis in the second study. Cox regressions need to be checked for proportional hazards. If conditional hazard rates cross each other along a variable, this means that the estimated effect varies within the model. The proportionality can be visualised and tested using Schoenfeldt residuals. While non-proportionality does not bias the average coefficient, it means that one cannot investigate how a coefficient changes along some explanatory variable of interest.

5 Results

5.1 Summary of the papers included in this thesis

Paper 1

From the eighteenth century and onwards, human mortality started declining across Europe and North America. In time, life expectancy was raised to unprecedented levels. This mortality decline has been argued to be a cornerstone in the creation of modern economic growth (Galor, 2012). In spite of its importance, there are still many questions left to answer regarding the factors driving the mortality decline. Being a phenomenon that is potentially influenced by many different societal changes, the debate on determinants has been long and diverse, and is still ongoing. Following McKeown et al. (1972) and their argument of nutrition as the main driving factor, others have proposed advances in medicine (Lee, 2003), declining virulence of major diseases (Fridlizius, 1985) and public investments in sanitation and hygiene (Alsan and Goldin, 2015; Cutler and Miller, 2005a). Although it is obvious that not one factor is behind the whole of the mortality decline, research has not yet presented a consistent view on the magnitude of each factor's contribution. Knowing more about what drove the mortality decline is of historical value, since it is a process of importance to the evolution of modern society. Apart from this relevance, the similarity between nineteenth/twentieth century European cities and slum areas in the Global South today has been used as an argument to study the efficiency of past interventions (Fewtrell et al., 2005; Ferrie and Troesken, 2008).

This first paper of the dissertation aims to add to the knowledge on determinants of mortality decline by studying an important public investment in Swedish cities: the building of water and sewerage networks. Regarded by a number of authors to be an important determinant (Kesztenbaum and Rosenthal, 2017; Chapman, 2019), most of the empirical evidence to date are studies of one large city in North America or Europe (Cutler and Miller, 2005a; Alsan and Goldin, 2015; Beemer et al., 2005; Kesztenbaum and Rosenthal, 2017; Van Pop-

pel and Van der Heijden, 1997; Burström et al., 1999), although a few exceptions consider a number of cities/areas (Troesken, 2002; Peltola and Saaritsa, 2019; Ogasawara and Matsushita, 2018; Cain and Rotella, 2001; Hinde and Harris, 2019). Sweden has mainly been researched in detailed studies of individual cities (Nilsson, 1994; Castensson et al., 1988; Burström et al., 2005, 1999; Knutsson, 2020), but a comprehensive story has yet to be presented.

This study contributes with a nation-wide perspective, exploiting a newly digitised database on Swedish cities between 1875 and 1930. By covering an almost full range of cities within the same national context, the magnitude of a public investment can be tested in a setting that has yet to be studied. The city-level panel, including high-precision measures of water and sewerage investments, as well as other health-related interventions, is analysed using a fixed-effects setup with a negative binomial count estimator. The timing of water and sewerage investments is argued, following Cutler and Miller (2005a), to be "plausibly" exogenous because of the differences between cities in political processes preceding these expensive public investments. To the extent that this assumption holds, the results can be interpreted in causal terms.

The results show an overall mortality reduction of 9% in waterborne disease mortality, and corresponding reductions of all-cause mortality (5%) and infant mortality (5%), from the introduction of water and/or sewerage systems. The reliability of these results is reinforced by the absence of an effect for airborne disease mortality. A sub-analysis of implementation sequencing shows that there are, as has been suggested by Alsan and Goldin (2015), complementary effects from having both water and sewerage installed. The magnitude of the results can be considered from several angles. As shown in a supplementary analysis of larger cities (Table 7), the results are of higher magnitude in cities above the median population in 1875 (-22%). The 9% reduction should thereby be interpreted as a proper national average which contains heterogeneities in size. Putting the results in perspective of the general decline in water-borne disease mortality during the period (Figure 3), the 9% average decline is measured against a 92% total decline (from 2.81 in 1875 to 0.23 in 1930). This gives that water and sewerage investments were responsible for roughly 10% of the decline, which is arguably a low figure. Focusing on the result from bigger cities, the contribution is closer to 24% of the decline (0.22/0.93, calculated from the average decline in the sample of bigger cities). Taken together, these results show that water and sewerage investments were a solid contribution to the Swedish mortality decline, but more so in bigger cities.

The results add important information regarding the magnitude of effects from these public investments. Compared to results from larger U.S. cities, the magnitude observed here is smaller. This is most likely explained by the fact that Swedish cities were at the time small in comparison. Also, the Swedish mortality decline had started well in advance of the building of water and sewerage systems, which would explain why the results are not as dramatic as observed elsewhere. The empirical results therefore tie well into what Nilsson (2013)

hypothesised: the water and sewerage investments in Sweden did not start the decline in water-borne disease mortality, but strengthened it and ensured that the rates stayed on very low levels.

This study of the Swedish experience shows that water and sewerage are important drivers of mortality decline, also in settings with less congested cities. Viewed in a larger perspective, they also show that water and sewerage are parts of a larger range of factors when it comes to explaining what drove the mortality decline in Sweden.

Paper 2

From the historical macro-level results of the first paper, the remaining papers move into the micro-level. Having shown the overall mortality benefits from water services in Swedish cities in paper 1, these studies zoom in on the largest city in Sweden: Stockholm. From the focus on health and mortality, paper 2 shifts to a more nuanced view on the mechanisms behind water provision by focusing on population access to water. An urban water network is an enormous and slow building project. The majority of studies on effects of water either consider finished projects, or cannot discriminate between who has access and who has not in cities where the network does not reach everyone. For example, the study by Cutler and Miller (2005a) considers the timing when the majority of the population had access to water. This is problematic, since in the case where ongoing projects are studied, there is no way of formally connecting the water access to changes in health measures observed. One can observe falling rates of waterborne disease mortality overall, or specifically within social groups, but without precise water access data, the link cannot be drawn to changes in water access. Furthermore, previous research has not yet been able to evaluate in detail how different types of urban governance choices managed to solve the problem of delivering water. A multitude of systems have been observed in previous studies, all on a scale between public and private. For example, Hassan (1984) describes the unequal water access outcomes from a private actor in Manchester, UK. However, no previous studies have been able to show population access outcomes using detailed data on population and water access.

It is therefore important to know more about how urban water systems spread and how the population groups in a city are given access to them. Much as with the previous study, the relevance of this is both historical and modern. Historically, very little is known about access to water during industrialisation, and empirical results are needed to understand the role of water systems in health inequalities. A deeper understanding of urban demographic history can also be informative in modern times. The spatial composition of social groups and the conditions for public and private actors are potentially very different then and now, but this is an area where we lack insights. The differences are important in order to know how much historical results are valid today.

This study aims to show how access to the water network was distributed between social groups during the network building period in Stockholm, specifically in the area of Södermalm. In addition, it aims to investigate if there were certain types of buildings that were connected to the network earlier, based on their SES profile. In doing this, the study will provide a description of how a water system spreads, and who gets access to it first. The data used is a micro-level population registry (the Roteman archives) which has been connected to a newly digitised building-level dataset on timing of water access. This level of precision is unique for a study of a nineteenth-century city. Also, a spatial dimension is added to the Roteman archives as a part of this study, which allows for analysis of network spread as well as access. The method used is an event history model, analysing building-level determinants of access while taking the growth of the network into account. In combination with the descriptive results, a multifaceted story can be told about growth and population access outcomes.

The results show that at study start, the network reached around 50% of Södermalm's population. A basic model suggests a slight SES gradient in that buildings with a higher white-collar share were more likely to be connected to the network. The main results, modelling buildings that were not yet connected in 1878, show two interesting findings. First, the time-to-connection models shows no SES gradient in connection to the network. The model predicts that a building with a higher population is more likely to be connected early, regardless of SES status. Second, the cross-sectional access outcomes show a difference in access between low/unskilled (50%) and white-collar (75%) households in Södermalm during the first year of study. Within ten years, as the network grows, the difference is less than half of this, and the gap all but closes at the end of the study period. The external validity of the results is potentially compromised by its temporal and spatial restriction of only observing Södermalm which was halfway in its building process at study start.

In summary, the results show a situation where the water network has grown seemingly without SES bias and access has spread based on building population size rather than SES profile. An interpretation of the results is that the city of Stockholm succeeded in its intended roll-out of the system. The explicit intention was to make water accessible for all SES groups, and this was manifested through low pricing and public ownership of the system. Although factors working in the opposite direction also existed (such as the unequal political representation system), these seem to have been overcome. An important part of the mechanism is the residential integration of social classes all the way down to the building level. Without this, an access spread as the one observed in this study would be theoretically impossible. This raises questions concerning the comparison with today's cities in the Global South, where the socio-spatial distribution is likely very different from industrialising cities in Europe and North America.

Paper 3

Having established the access outcomes of the public water investments in Stockholm, the third paper takes the mortality study of the first paper to the micro-level. Health and mortality responses from societal changes can be measured at different levels of aggregation, and across different time-scales. Whereas studies on a macro-level can provide knowledge on broader developments in a nation or city, they do not inform us of the detailed mechanisms. Mortality determinants at the micro-level are closely linked to variables operating specifically on this level, and this is especially true for infant and child mortality. As has been shown in paper 2, the relation between access to protective factors and SES is likely to confound any estimations of mortality at an aggregate level, which is potentially relevant for water investments as well as other protective factors. If we want to know more about how the determination of mortality actually works when variables operate at different levels, we need to model at the highest precision. Much of the previous research in this field has been done on the city-level. The results have generally shown large magnitudes, finding mortality reductions of around 40% in infant mortality (Cutler and Miller, 2005a, 2019), and 30-50% in all-cause mortality (Ferrie and Troesken, 2008) associated with investments in water systems and water purification. In these studies, as was done in paper 1, assumptions need to be made regarding the distribution of access among SES groups. While these city-level results are still valuable as total effects, they do not tell us which variables operate at the individual level, and whether these are the same as at the macro-level.

This study exploits the Roteman archives together with the water registry, which makes it possible to create an individual-level panel of all residents in Södermalm, Stockholm, with the water access status at its most precise level (the building). With this panel, it is possible to properly account for time-at-risk, since migrations between buildings and city districts are reported. As the Roteman archives also contain household identifiers, important variables such as household-level SES and persons present in the household (as a proxy for residential crowding) at a given time can be taken into account. The study population consists of all children between ages 0 to 10 ever living in the study area Södermalm between 1878 and 1915. Mortality hazards are estimated as a function of water access and a range of household- and building-level controls, using a Cox proportional hazards estimator. The models have been run for the age groupings 0-1, 1-5 and 5-10.

The results show that while access to water was associated with a 5% mortality hazard reduction, the coefficient for water access is not robust to the inclusion of household SES for the two older age categories. Furthermore, the effect size shrinks considerably when controlling for household-level SES: for infants, the effect becomes around 40% lower. The magnitude of other common mortality determinants, such as illegitimacy status and gender, is markedly larger than the water access coefficient, as is the SES coefficient. Models investigating heterogeneous effects find that the results for infants is largely driven by

boys, and that the effect of water access does not differ by SES status.

The magnitude of results differs from what has been found in previous research efforts. Although a direct comparison is difficult due to differences in estimation and levels of aggregation, the 5% hazard reductions are very different from the 40% reductions presented above. A possible explanation for the differences in results is that household SES accounts for a larger share of the mortality decline than previously found - since this SES effect can mask as water effects in aggregate data. Possibly contributing to the lower magnitude of results is also the period studied, which is the second half of the implementation of the Stockholm water system. In summary, this study shows that the mortality effect of water access in Södermalm was lower than expected, and primarily observable for infant boys. As far as the results can be compared to the most influential previous studies, these results suggest that household SES may be behind a larger share of what has previously been identified as water access effects on mortality.

Paper 4

Paper 4 takes up where paper 2 left off, shifting the focus to what happens after a building has been connected to the network. This study moves further into the dynamics of urban networks and how they interact with a city's population, and does this by focusing on the concept of neighbourhood change. Neighbourhood change is a process wherein cities and neighbourhoods react and respond to actions by private and public actors, and is often measured by changes in property values or social profiles of areas. A commonly studied form of neighbourhood change is gentrification, wherein lower-SES residents are replaced with higher-SES residents. A changing neighbourhood can mean that the prerequisites for living there are altered, which can in turn exclude both current and potential future residents of certain social groups.

Previous research on neighbourhood change has mainly focused on the role of private capital and private actors as the most important agents of change (Zuk et al., 2018). Theories on gentrification include both consumption-side (such as changing housing preferences for higher-SES groups) and production-side (such as the rent gap theory by Smith (1979)) angles to explain why some neighbourhoods undergo changes of social status. In recent years, a literature on the effects of network-oriented public investments within transport has emerged (Kahn, 2007; Zheng and Kahn, 2013; Kilpatrick et al., 2007; Bardaka et al., 2018), but the evidence regarding public health infrastructure is still scarce.

Furthermore, there is little empirical evidence from cities during industrialisation. Although this is likely due to lack of precise data, there is ample reason to study European and North American cities of the nineteenth and twentieth century. This period saw the beginnings of modern urban governance from public actors, often in combination with

economic growth and periods of high in-migration. Taken together, this period in urban history gives interesting opportunities to study the dynamics of public and private actors and the interplay with neighbourhood choice and constraint. Stockholm, the city of study, relied heavily on public actors in the implementation of public network infrastructure, but the outcomes for neighbourhood change in such a setting has not yet been studied.

This study makes use of the aforementioned individual-level population database of Stockholm between 1878 and 1926 (the Roteman archives) in combination with high-precision data on the roll-out of a public investment (the water network). This data is used to analyse the potential effects on neighbourhood change from the growth of the network throughout the study area (Södermalm). Since running water in a building was at the time something of a novelty, theory suggests that this would affect the desirability of the connected buildings. This could in turn affect rents, which would mean changing prerequisites for lower-SES residents. The expansion of the public network could create a situation which Renne et al. (2016) call an "affordability paradox" from public investments: the ones in most need of the investment (lower-SES residents) are driven out of access because of external effects from the same investment. The study uses a yearly panel of buildings which is modelled using a fixed-effects OLS estimator.

The model results show that a building connected to the water network experiences an upwards change in trend of its SES profile. A connected building is predicted to increase its white-collar share with 5-6% over a 30-year period, compared to a building that is not connected (all else equal). The increase should be viewed against a baseline of 12% white-collar share. No level effect is found in the models. The sensitivity of the results is tested by restricting the years analysed to +/- 5 and 10 years around the installation year, to which the results are robust.

The results from this study thereby show that a public health investment can have a slow but stable effect on the socio-spatial composition of a neighbourhood. The magnitude of the effect is not dramatic, but seen against the relatively low starting point, it is still substantial. The absence of a direct level effect shows that the city succeeded in preventing that the yearly water tax affected rents directly after installation in a building. The intention of the city, which explicitly was to make water accessible for all social groups, was arguably realised. However, the city could not prevent long-term changes in desirability of connected buildings.

6 Concluding discussion

The industrialisation process in Sweden coincided with groundbreaking changes in conditions for living in cities. The period between the mid-nineteenth and mid-twentieth

centuries saw a massive increase in public investments in cities, within health and education as well as networked infrastructure, such as water, sewerage, electricity, transportation and communication. Simultaneously, patterns of socio-spatial segregation changed towards higher levels of SES-based segregation between buildings and neighbourhoods. At the end of the period, the urban mortality penalty had disappeared and, as has been shown for Stockholm, horizontal segregation of social classes was on the rise. Covering this dynamic period in Swedish urban history, this dissertation contributes to our understanding of how public investments shaped health outcomes, while also giving insights into how they interplay with the urban population and building market.

As a starting point, it is worthwhile to return to the questions asked in the first chapter. It is clear that there is much we do not know about determinants of mortality decline, and also the mechanisms and consequences of public investments in cities. In the first chapter, it was speculated that the time period, context and, most importantly, level of aggregation of our data will be of great consequence for the answers we get. As it turns out, studying Swedish cities during industrialisation, and Stockholm at the micro-level in particular, rendered answers that were markedly different from much of what has come before. Partly, this is likely due to the fact that Sweden had a different urban context compared to previous research, but the results from the micro-level add new information and raise further questions.

This dissertation has had two main aims, which we can now briefly return to before continuing the discussion. The first aim, covering studies number one and three, was to show how health and mortality were affected by public investments in Swedish cities during industrialisation. This aim was addressed by studying the mortality effects of water and sewerage investments on the city level, and also by studying effects of water access on young-age mortality at the micro-level. The second aim of the dissertation was to study how public investments integrate in society, with a focus on how they spread in a city and how their external effects can affect neighbourhoods. Specifically, studies number two and four address this aim by showing determinants of access to the water network in Stockholm, and by showing how the SES status of a building can change after connection to this network.

The main contribution of this dissertation is showing mortality outcomes at different levels (from the city to the individual) of the same public investment during a very dynamic period in Swedish history. Additionally, this dissertation has described two angles of an urban public investment that have rarely been studied in detail before: what determines how access is distributed among SES groups, and what are the external effects that the investment might have on the building market - which in turn can affect access?

The two studies within the first aim, concerning health and mortality, show - perhaps surprisingly - results that are of comparatively low magnitudes. Returning to the question asked in the first study, concerning the impact of water and sewerage on the Swedish mor-

tality decline, the results show that the systems have had a solid but comparatively modest effect in bringing down mortality in Sweden. Additional analysis shows that the two types of systems complement each other, which is confirmed by analysing the sequence with which they are implemented. These results add to the literature by affirming that city size matters in discussions of mortality and its determinants. The size of cities is important in two ways: it is likely that the lower congestion of people plays a role in creating a less intensive disease environment. Additionally, it is possible that the precision of timing of investments is more easily measured in a smaller city, since it should correspond to a point in time when at least a majority of the population has access. Compared to studies on larger cities, this means that the results from this dissertation can be argued to have less measurement errors. Furthermore, the results on complementarity of systems tie into the literature concerning diffusion of water-borne disease, and emphasise that both primary and secondary barriers play a large role in reducing the spread. This is a clear contribution to the literature, since few other studies have showed the two systems in a large number of cities while taking the complexity of their timing into account.

The third study, making use of micro-level data, also deviates from what has been previously found. Although some mortality effects of water access are observed in limited model specifications, especially for infant boys, the full model specifications show that SES at household, building and neighbourhood levels remove both the size and statistical significance of the water access variable. There could be a number of explanations behind this result, and as mentioned in the study, residual SES effects and selective migration are deemed the most likely. The results from the third study of the dissertation raise important questions regarding how health and mortality determinants could and should be evaluated. To the extent that Stockholm's experience with the water network is externally valid, the results highlight the importance of evaluating at different levels. SES is found to be much more important than previously found, and what is embedded in this SES variable can only be speculated as of now. What is clear, however, is that micro-level research can shed new light on results that have thus far been accepted as explanations to a historical course of events. Naturally, it is possible that the results from Stockholm are partly a product of context, since only the later half of the implementation is observed. On the other hand, it is also possible that the Stockholm results reflect a more complex relation between water access, SES and mortality. If this is the case, previous results from other cities might also reveal a different picture, were they to be tested with precisely identified determinants. Theoretically, this reasoning extends also to other determinants of mortality that have thus far been evaluated using aggregated data. The results from this dissertation should therefore be taken as an encouragement for more research at the micro-level.

Regarding the second aim, how public investments integrate in society, this dissertation adds new perspectives on how access is determined, but also how external effects can have long-term consequences. Theory and previous research do not leave a comprehensive ex-

pectation of how public investments allocate over time, space or among social classes. The two studies on Stockholm in this dissertation contribute with empirical evidence regarding how spatially bound public investments spread, and the external effects they create in the long run. In paper 2, the question was asked if there were inequalities of access to the water network in Stockholm, and what were the determinants of getting connected earlier? The results show that there were access inequalities between the highest and lowest social classes, but these were arguably not large and disappeared quickly. The further results, showing that building social status mattered less than population size in time to connection, are a first of their kind and a novel contribution to the literature. The Stockholm water network was a case where the intentions of the city council, which were explicit in striving for universal access, seem to have been successfully executed. Although there are few other studies relying on detailed data to compare with, the results indicate that public provision created a more equal access distribution across social groups, not only when the network was finished but also during its long building period. These results show there is much to be learned by not only analysing large-scale public investments post factum, but following them as they unfold.

The spatial dimension is a crucial part of the interpretation. Stockholm was, at the start of the study period, a city where socio-spatial residential segregation was still vertical rather than horizontal. Naturally, residential segregation is always a question of scale and degree, but the current results have allowed for measuring segregation at its most detailed level: the building. 90% of the buildings in the study area had presence of both the lowest and highest classes at the start of the period. Assuming, then, that higher social classes would have the monetary and political resources to gain access before lower classes, the spatial integration would give lower classes access by proxy. This mechanism, it should be noted, functions in the case of network-based investments where no other barriers to access (such as monetary or rule-based) are in place. After political struggles, the city of Stockholm decided to remove such barriers by setting an affordable tax and making it illegal to discriminate within buildings. The results from this dissertation can not separate the contributions of public provision and residential integration, but it seems likely that they were both prerequisites for the equal spread observed in this study. By describing an implementation of a public investment as it unfolds, these political and spatial mechanisms show that Stockholm during industrialisation was a perhaps surprisingly equal city when it came to access to water.

Further results complicate the story. Public investments need also to be considered as parts of the regular building market, where location and proximity to desirable amenities can dictate rents and prices. In this manner, Stockholm is a suitable city to study, since it was almost completely a rental market with no regulations, which removes obstacles for entry and allows market forces to work undisturbed. The fourth paper in this dissertation addresses the external effects of public investments by asking: did buildings connected to the water network in Stockholm experience a shift in social composition, and what was

the nature of this shift? The results, which show a trend but no immediate level effect, corroborate the interpretation that the water tax was affordable for lower social classes. The trend, however, is indicative of a push- or pull-mechanism which gradually replaces lower-class residents with those of a higher class. The exact mechanism is likely to be connected to higher-class preferences for either water access, or for living in a building with other higher-class residents. The latter would be a sorting mechanism as described by Schelling (1969).

The results can be compared to the literature on modern public investments (mainly regarding transport infrastructure) where gentrification is suggested as an outcome in buildings close to the network. While not directly comparable, the results from this dissertation are an addition to the field by considering a city during industrialisation. An important question regarding the results is: what are the policy implications? These can be argued to be problematic, as it would be strange to suggest that public investments should be avoided with reference to their potential to disturb building markets. While it is hard to dictate policy on the matter, the results from this dissertation show that external market effects are important to weigh in when a public investment is planned, irrespective of the initial intentions. This dissertation adds to the debate by researching neighbourhood change in an industrialising city, using comparatively precise data on a networked public investment. Although this cannot solve the common problems of the field, such as the lack of information on reasons for migration, it nevertheless comes closer to a valid estimate by narrowing the scope of analysis around the years of installation in a building.

This dissertation demonstrates clearly that public investments in cities are well worth studying in closer detail and from new angles. Historically, water networks were important in bringing down mortality, especially together with sewerage. The size of the contribution was, in the case of Sweden, smaller than what has previously been found. Moreover, when analysed in detail, household SES was the most important determinant of mortality at younger ages and overshadows the effect from access to water. This result raises important questions regarding the role of SES in mortality decline, which is likely more prominent than what we have understood until now. Regarding the spread and external effects of public investments, the results show that it was possible to avoid large inequalities of access in a growing industrialising city. This was made possible both deliberately by the decisions of the public actor, but also mechanically due to residential integration. The investments did, however, play a part in changing the social composition of connected buildings in the long run. The dissertation is definitely not the last word in any these topics, but it shows that geographically coded population data can help us understand how cities were shaped through public investments.

7 References

Aaby, P. (1992). Lessons for the past: Third World evidence and the reinterpretation of developed world mortality declines. *Health Transition Review*, pages 155–183.

Allison, P. (2014). *Event History and Survival Analysis*. SAGE Publications, Inc., 2455 Teller Road, Thousand Oaks California 91320 United States.

Allison, P. D. (2009). *Fixed effects regression models*, volume 160. SAGE publications.

Alsan, M. and Goldin, C. (2015). Watersheds in Infant Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880 to 1915. Technical report, National Bureau of Economic Research.

Alsan, M. and Goldin, C. (2019). Watersheds in child mortality: the role of effective water and sewerage infrastructure, 1880–1920. *Journal of Political Economy*, 127(2):586–638.

Anderson, D. M., Charles, K. K., and Rees, D. I. (2018). Public health efforts and the decline in urban mortality. Technical report, National Bureau of Economic Research.

Antonovsky, A. (1967). Social class, life expectancy and overall mortality. *The Milbank Memorial Fund Quarterly*, 45(2):31–73. Publisher: JSTOR.

Atkinson, R. (2000). The hidden costs of gentrification: Displacement in central London. *Journal of housing and the built environment*, 15(4):307–326. Publisher: Springer.

Bardaka, E., Delgado, M. S., and Florax, R. J. (2018). Causal identification of transit-induced gentrification and spatial spillover effects: The case of the Denver light rail. *Journal of Transport Geography*, 71:15–31.

Bartram, J. and Hunter, P. (2015). Bradley classification of disease transmission routes for waterrelated hazards.

Beach, B., Ferrie, J., Saavedra, M., and Troesken, W. (2016a). Typhoid fever, water quality, and human capital formation. *The Journal of Economic History*, 76(01):41–75.

Beach, B., Troesken, W., and Tynan, N. (2016b). Who should own and control urban water systems? Historical evidence from England and Wales. Technical report, National Bureau of Economic Research.

Beemer, J. K., Anderton, D. L., and Leonard, S. H. (2005). Sewers in the city: A case study of individual-level mortality and public health initiatives in Northampton, Massachusetts, at the turn of the century. *Journal of the history of medicine and allied sciences*, 60(1):42–72.

Bengtsson, E., Missiaia, A., Olsson, M., and Svensson, P. (2018). Wealth inequality in Sweden, 1750–1900. *The Economic History Review*, 71(3):772–794.

Bengtsson, T. and Dribe, M. (2011). The late emergence of socioeconomic mortality differentials: A micro-level study of adult mortality in southern Sweden 1815–1968. *Explorations in Economic History*, 48(3):389–400.

Bengtsson, T., Dribe, M., and Helgertz, J. (2020). When did the health gradient emerge?: Social class and adult mortality in southern sweden, 1813-2015. *Demography*, 57(3):953–977.

Bengtsson, T. and Ohlsson, R. (1994). The demographic transition revised. In *Population, Economy, and Welfare in Sweden*, pages 13–36. Springer.

Bernhardt, E. M. (1995). Crowding and survival in Stockholm 1895-1920.

Blum, A., Houdaille, J., and Lamouche, M. (1990). Mortality differentials in France during the late 18th and early 19th centuries. *Population an English Selection*, pages 163–185. Publisher: JSTOR.

Broström, G. (2018). *Event history analysis with R*. CRC Press.

Brändström, A. (1993). Infant mortality in Sweden 1750–1950: Past and present research into its decline. In *The decline of infant and child mortality: the European experience, 1750-1990*. Martinus Nijhoff Publishers.

Brändström, A., Edvinsson, S., and Rogers, J. (2000a). Infant Mortality in Sweden; Creating Regions from Nineteenth-Century Parish Data. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, 33(2):105–114.

Brändström, A., Sundin, J., and Tedebrand, L.-G. (2000b). Two cities: Urban Migration and Settlement in Nineteenth-Century Sweden. *The History of the Family*, 5(4):415–429. Publisher: Elsevier.

Burström, K., Johannesson, M., and Diderichsen, F. (2005). Increasing socio-economic inequalities in life expectancy and qalys in sweden 1980–1997. *Health economics*, 14(8):831–850.

Burström, B. and Bernhardt, E. (2001). Social differentials in the decline of child mortality in nineteenth century Stockholm. *The European Journal of Public Health*, 11(1):29–34. Publisher: Oxford University Press.

Burström, B., Diderichsen, F., and Smedman, L. (1999). Child mortality in Stockholm during 1885–1910: the impact of household size and number of children in the family on the risk of death from measles. *American journal of Epidemiology*, 149(12):1134–1141.

Burström, B., Macassa, G., Öberg, L., Bernhardt, E., and Smedman, L. (2005). Equitable Child Health Interventions: The impact of improved water and sanitation on inequalities in child mortality in Stockholm, 1878 to 1925. *American Journal of Public Health*, 95(2):208–216.

Burström, B. and Öberg, L. (2006). The dialectics of childhood diarrhea mortality. *International Journal of Health Services*, 36(3):481–501. Publisher: SAGE Publications Sage CA: Los Angeles, CA.

Cain, L. and Rotella, E. (2001). Death and spending: urban mortality and municipal expenditure on sanitation. In *Annales de démographie historique*, pages 139–154. Belin.

Castensson, R., Löwgren, M., and Sundin, J. (1988). Urban water supply and improvement of health conditions. *Society, health and population during the demographic transition*, pages 273–298.

Chapman, J. (2018). Democratic reform and opposition to government expenditure: Evidence from nineteenth-century Britain.

Chapman, J. (2019). The contribution of infrastructure investment to Britain's urban mortality decline, 1861–1900. *The Economic History Review*, 72(1):233–259. Publisher: Wiley Online Library.

Chetty, R., Stepner, M., Abraham, S., Lin, S., Scuderi, B., Turner, N., Bergeron, A., and Cutler, D. (2016). The Association Between Income and Life Expectancy in the United States, 2001-2014. *JAMA*, 315(16):1750–1766.

Clouston, S. A., Rubin, M. S., Phelan, J. C., and Link, B. G. (2016). A social history of disease: contextualizing the rise and fall of social inequalities in cause-specific mortality. *Demography*, 53(5):1631–1656.

Corsini, C. and Viazzo, P. (1997). *The Decline of Infant and Child Mortality: The European Experience, 1750-1990*. Springer Netherlands.

Cronström, A. (1986). Stockholms tekniska historia. *Vattenförsörjning och avlopp. Stockholms VA-verk och kommittén för Stockholmsforskning*.

Cutler, D., Deaton, A., and Lleras-Muney, A. (2006). The Determinants of Mortality. *Journal of Economic Perspectives*, 20(3):97–120.

Cutler, D. and Miller, G. (2005a). The role of public health improvements in health advances: the twentieth-century United States. *Demography*, 42(1):1–22.

Cutler, D. and Miller, G. (2005b). Water, water, everywhere: municipal finance and water supply in American cities. Technical report, National Bureau of Economic Research.

Cutler, D. M. and Miller, G. (2019). Comment on'Pubic Health Efforts and the Decline in Urban Mortality'. *Available at SSRN 3312834*.

Davis, K. (1945). The world demographic transition. *The Annals of the American Academy of Political and Social Science*, 237(1):1–11.

DDSS (2020). Demografisk Databas Södra Sverige: Dödsorsaker och sjukdomsnamn.

Deaton, A. (2013). *The great escape: health, wealth, and the origins of inequality*. Princeton University Press.

Deaton, A. (2016). On death and money: history, facts, and explanations. *Jama*, 315(16):1703–1705. Publisher: American Medical Association.

Debiasi, E. and Dribe, M. (2020). SES inequalities in cause-specific adult mortality: a study of the long-term trends using longitudinal individual data for Sweden (1813–2014). *European journal of epidemiology*, 35(11):1043–1056. Publisher: Springer.

Delmelle, E. C., Nilsson, I., and Bryant, A. (2020). Investigating Transit-Induced Displacement Using Eviction Data. *Housing Policy Debate*, pages 1–16. Publisher: Taylor & Francis.

Duffy, J. (1992). *The sanitarians: a history of American public health*. University of Illinois Press.

Duflo, E., Greenstone, M., Guiteras, R., and Clasen, T. (2015). Toilets can work: Short and medium run health impacts of addressing complementarities and externalities in water and sanitation. Technical report, National Bureau of Economic Research.

Easterlin, R. A. (1999). How beneficent is the market? A look at the modern history of mortality. *European Review of Economic History*, 3(3):257–294.

Edvinsson, S. (1992). Den osunda staden: sociala skillnader i dödlighet i 1800-talets Sundsvall.

Edvinsson, S. (1995). Mortality and the urban environment: Sundsvall in the 1880's. Publisher: Demografiska databasen, Ume\aa universitet.

Edvinsson, S. (2015). Hälsoreformer, livsmedelskontroll och hälsoutveckling i svenska städer 1850-1930.

Elo, I. T. (2009). Social class differentials in health and mortality: Patterns and explanations in comparative perspective. *Annual review of sociology*, 35:553–572.

Elo, I. T. and Preston, S. H. (1996). Educational differentials in mortality: United States, 1979–1985. *Social science & medicine*, 42(1):47–57. Publisher: Elsevier.

Fariñas, D. R. and Oris, M. (2016). *New Approaches to Death in Cities during the Health Transition*. Springer.

Ferrie, J. P. and Troesken, W. (2008). Water and Chicago's mortality transition, 1850–1925. *Explorations in Economic History*, 45(1):1–16.

Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L., and Colford, J. M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *The Lancet infectious diseases*, 5(1):42–52.

Floris, J. and Staub, K. (2019). Water, sanitation and mortality in swiss towns in the context of urban renewal in the late nineteenth century. *The History of the Family*, 24(2):249–276.

Fogel, R. W., Engerman, S. L., Trussell, J., Floud, R., Pope, C. L., and Wimmer, L. T. (1978). The economics of mortality in north america, 1650–1910: A description of a research project. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, 11(2):75–108.

Fransham, M. (2020). Neighbourhood gentrification, displacement, and poverty dynamics in post-recession england. *Population, Space and Place*, page e2327.

Freeman, L. and Braconi, F. (2004). Gentrification and displacement New York City in the 1990s. *Journal of the American Planning Association*, 70(1):39–52. Publisher: Taylor & Francis.

Fridlizius, G. (1985). The mortality decline in the first phase of the demographic transition: Swedish experiences.

Galiani, S., Gertler, P., and Schargrodsky, E. (2005). Water for life: The impact of the privatization of water services on child mortality. *Journal of political economy*, 113(1):83–120.

Galor, O. (2012). The demographic transition: causes and consequences. *Cliometrica*, 6(1):1–28.

Galster, G. C. (2019). *Making our neighborhoods, making our selves*. University of Chicago Press.

Gandy, M. (2004). Rethinking urban metabolism: water, space and the modern city. *City*, 8(3):363–379.

Gejvall, B. (1987). *1800-talets Stockholmsbostad- En studie over den borgerliga bostadens planlösning i hyreshusen*. Stockholm stads monografiserie, del 16.

Geschwind, A. and Fogelvik, S. (2000). The Stockholm historical database. *Handbook of international historical microdata for population research*, pages 207–230.

Glass, R. (1964). Aspects of change. *The gentrification debates: A reader*, pages 19–30. Publisher: Routledge.

Grier, G. and Grier, E. (1978). *Urban displacement: A reconnaissance*. Department of Housing and Urban Development.

Grähs, C. (1875). *Kongl. Sundhets-Kollegium: Embetsberättelse 1875*.

Hagberg, A., Swart, P., and S Chult, D. (2008). Exploring network structure, dynamics, and function using NetworkX. Technical report, Los Alamos National Lab.(LANL), Los Alamos, NM (United States).

Hallenberg, M. (2018). *Kampen om det allmänna bästa: Konflikter om privat och offentlig drift i Stockholms stad under 400 \a ar*. Nordic Academic Press.

Hammel, D. J. (2009). Gentrification. In Kitchin, R. and Thrift, N., editors, *International Encyclopedia of Human Geography*, pages 360 – 367. Elsevier, Oxford.

Harvey, D. (1973). *Social justice and the city*, volume 1. University of Georgia Press.

Hassan, J. A. (1984). The impact and development of the water supply in Manchester 1568–1882. *Transactions of the Historic Society of Lancashire and Cheshire*, 133:25–45.

Hassan, J. A. (1985). The growth and impact of the British water industry in the nineteenth century. *Economic History Review*, pages 531–547.

Hayward, M. D., Hummer, R. A., and Sasson, I. (2015). Trends and group differences in the association between educational attainment and US adult mortality: Implications for understanding education's causal influence. *Social Science & Medicine*, 127:8–18. Publisher: Elsevier.

Hedin, K., Clark, E., Lundholm, E., and Malmberg, G. (2012). Neoliberalization of housing in Sweden: Gentrification, filtering, and social polarization. *Annals of the Association of American Geographers*, 102(2):443–463. Publisher: Taylor & Francis.

Hedman, E. (2008). Den kommunala allmännyttans historia-särtryck av underlag till utredningen om allmännyttans villkor (sou 2008: 38). *Karlskrona: Boverket*.

Henning, M., Enflo, K., and Andersson, F. N. (2011). Trends and cycles in regional economic growth: How spatial differences shaped the swedish growth experience from 1860–2009. *Explorations in Economic History*, 48(4):538–555.

Hinde, A. and Harris, B. (2019). Mortality decline by cause in urban and rural england and wales, 1851–1910. *The History of the Family*, 24(2):377–403.

HMD (2020). Sweden, Life expectancy at birth (period, 1x1). Human Mortality Database. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany).

Hort, S. (2014). *Social policy, welfare state, and civil society in Sweden. Vol. 1: History, policies, and institutions 1884-1988*. Arkiv förlag & tidskrift.

Jaadla, H. and Puur, A. (2016). The impact of water supply and sanitation on infant mortality: Individual-level evidence from Tartu, Estonia, 1897–1900. *Population studies*, 70(2):163–179.

Jaadla, H. and Reid, A. (2017). The geography of early childhood mortality in England and Wales, 1881–1911. *Demographic Research*, 37:1861–1890. Publisher: JSTOR.

Kahn, M. E. (2007). Gentrification Trends in New Transit-Oriented Communities: Evidence from 14 Cities That Expanded and Built Rail Transit Systems. *Real Estate Economics*, 35(2):155–182.

Kalff, E. (1987). La sensibilisation à l'hygiène : Paris 1850-1880, la loi sur les logements insalubres. *Les Annales de la recherche urbaine*, 33(1):97–104.

Kazepov, Y. (2005). Cities of Europe: Changing contexts, local arrangements, and the challenge to social cohesion. *Cities of Europe*, 1:3–33.

Kesztenbaum, L. and Rosenthal, J.-L. (2017). Sewers' diffusion and the decline of mortality: The case of Paris, 1880–1914. *Journal of Urban Economics*, 98(Supplement C):174–186.

Kilpatrick, J., Throupe, R., Carruthers, J., and Krause, A. (2007). The impact of transit corridors on residential property values. *Journal of Real Estate Research*, 29(3):303–320. Publisher: American Real Estate Society.

Knox, P. and Pinch, S. (2014). *Urban social geography: an introduction*. Routledge.

Knutsson, D. (2020). The Effect of Water Filtration on Cholera Mortality. IFN Working Paper 1346, IFN.

Krause, M. (2008). *The political economy of water and sanitation in developing countries: Cross-country evidence and a case study on Colombia*. PhD Thesis, Universitätsbibliothek Giessen.

Lee, R. (2003). The demographic transition: three centuries of fundamental change. *The Journal of Economic Perspectives*, 17(4):167–190.

Lesger, C. and Van Leeuwen, M. H. (2011). Residential segregation from the sixteenth to the nineteenth century: evidence from the netherlands. *Journal of Interdisciplinary History*, 42(3):333–369.

Lindberg, F. (1980). *Växande stad: Stockholms stadsfullmäktige 1862-1900*. Stockholms kommunalförvaltning.

Lindert, P. H. (2004a). Growing Public (Vol. 2). *Further evidence: Social spending and economic growth since the eighteens century, Cambridge University Press, Cambridge and New York*.

Lindert, P. H. (2004b). *Growing public: Volume 1, the story: Social spending and economic growth since the eighteenth century*, volume 1. Cambridge University Press.

Lindman, C. (1911). *Sundhets-och befolkningsförhållanden i Sveriges städer 1851-1909. 2, Tabeller och diagram*. Nord. bokh.

Link, B. G. and Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of health and social behavior*, pages 80–94.

Logan, J. R. and Bellman, B. (2016). Before the philadelphia negro: Residential segregation in a nineteenth-century northern city. *Social science history*, 40(4):683–706.

Lundh, C. (2003). Den regionala befolkningsstatistiken i tabellverket-en databeskrivning. *Lund Papers in Economic History*, (91).

Lundh, C. (2006). Arbetskraftens rörlighet och arbetsmarknadens institutioner i sverige 1850-2005. *Arbetsrätt, rörlighet och tillväxt*, pages 17–62.

Løkke, A. (2002). Infant mortality in nineteenth century Denmark. Regionality, feeding habits, illegitimacy and causes of death. *Hygiea Internationalis*, 3(1):115–149. Publisher: Linköping University Electronic Press.

Macassa, G., Ponce de Leon, A., and Burström, B. (2006). The impact of water supply and sanitation on area differentials in the decline of diarrhoeal disease mortality among infants in stockholm 1878—1925. *Scandinavian journal of public health*, 34(5):526–533.

Mackenbach, J. P., Kunst, A. E., Cavelaars, A. E., Groenhof, F., Geurts, J. J., and Health, E. W. G. o. S. I. i. (1997). Socioeconomic inequalities in morbidity and mortality in western Europe. *The lancet*, 349(9066):1655–1659.

Magnusson, L. (2000). *An economic history of Sweden*, volume 16. Routledge.

Marcuse, P. (1985). Gentrification, abandonment, and displacement: Connections, causes, and policy responses in New York City. *Wash. UJ Urb. & Contemp. L.*, 28:195. Publisher: HeinOnline.

Marmot, M. G., Stansfeld, S., Patel, C., North, F., Head, J., White, I., Brunner, E., Feeney, A., and Smith, G. D. (1991). Health inequalities among British civil servants: the Whitehall II study. *The Lancet*, 337(8754):1387–1393. Publisher: Elsevier.

McKeown, T., Brown, R. G., and Record, R. G. (1972). An interpretation of the modern rise of population in Europe. *Population studies*, 26(3):345–382.

McKeown, T. and Record, R. G. (1962). Reasons for the decline of mortality in England and Wales during the nineteenth century. *Population studies*, 16(2):94–122.

McKinnish, T., Walsh, R., and White, T. K. (2010). Who gentrifies low-income neighborhoods? *Journal of urban economics*, 67(2):180–193. Publisher: Elsevier.

Mercer, A. (2014). *Infections, chronic disease, and the epidemiological transition: a new perspective*, volume 31. Boydell & Brewer.

Molitoris, J. (2015). *Life and Death in the City: Demography and Living Standards during Stockholm's Industrialization*, volume 73. Lund University.

Molitoris, J. (2017). Disparities in death: Inequality in cause-specific infant and child mortality in Stockholm, 1878–1926. *Demographic Research*, 36:455–500.

Mosley, W. H. and Chen, L. C. (1984). An analytical framework for the study of child survival in developing countries. *Population and development review*, 10:25–45.

Nilsson, H. (1994). Mot bättre hälsa: dödlighet och hälsoarbete i Linköping 1860-1894.

Nilsson, L. (1989). *Den urbana transitionen: tätorterna i svensk samhällsomvandling 1800-1980*. Stadshistoriska institutet.

Nilsson, L. (2013). Städerna 1860–1920. In *150 år av självstyrelse - Kommuner och landsting i förändring*. SKL, Sveriges Kommuner och Landsting.

Ogasawara, K. and Matsushita, Y. (2018). Public health and multiple-phase mortality decline: Evidence from industrializing japan. *Economics & Human Biology*, 29:198–210.

ONS (1921). Census of England and Wales: General report with appendices.

Padeiro, M., Louro, A., and da Costa, N. M. (2019). Transit-oriented development and gentrification: a systematic review. *Transport Reviews*, 39(6):733–754.

Peltola, J. and Saaritsa, S. (2019). Later, smaller, better? water infrastructure and infant mortality in finnish cities and towns, 1870–1938. *The History of the Family*, 24(2):277–306.

Perlinge, A. (2012). *Bubblan som sprack: byggboomen i Stockholm 1896-1908*. Stockholmia i samarbete med Centrum för näringslivshistoria.

Petersson, F. (2005). *Vattnets vägar - från vik till innergård på Södermalm 1880-1920*. Dokument & rapporter. Center for Health Equity Studies (Chess).

Porter, D. (1999). *Health, civilization, and the state: a history of public health from ancient to modern times*. Psychology Press.

Preston, S. H. and Haines, M. R. (1991). Fatal Years: Child Mortality in Late Nineteenth-Century America. Technical report, National Bureau of Economic Research.

Razzell, P. and Spence, C. (2006). The hazards of wealth: adult mortality in pre-twentieth-century England. *Social History of Medicine*, 19(3):381–405. Publisher: Oxford University Press.

Renne, J. L., Tolford, T., Hamidi, S., and Ewing, R. (2016). The Cost and Affordability Paradox of Transit-Oriented Development: A Comparison of Housing and Transportation Costs Across Transit-Oriented Development, Hybrid and Transit-Adjacent Development Station Typologies. *Housing Policy Debate*, 26(4-5):819–834. Publisher: Routledge _eprint: https://doi.org/10.1080/10511482.2016.1193038.

Riley, J. C. (2005). The timing and pace of health transitions around the world. *Population and Development Review*, 31(4):741–764.

Råberg, M. (1976). *En Framtid För 1800-Talets Stockholm?: Storstadens Framväxt Underindustrialismen: Aktuella Bevarande-Och Saneringsplaner*, volume 1. Stockholms stadsmuseum Stockholm. Publication Title: Stadsvandringar.

SCB (1851). Bidrag till Sveriges officiella statistik (BiSOS) A: Befolkningsstatistik. Technical report.

SCB (1861). Bidrag till Sveriges officiella statistik (BiSOS) K: Hälso- och sjukvården. Technical report.

SCB (1911a). Sveriges officiella statistik: Allmän hälso- och sjukvård. 1911-1935, annual volumes. Technical report, Stockholm.

SCB (1911b). Sveriges officiella statistik: Befolkningsrörelsen. 1911-1935, annual volumes. Technical report, Stockholm.

SCB (1969). *Del 1. Befolkning. Andra upplagan. 1720–1967*. Stockholm: SCB.

Schelling, T. C. (1969). Models of segregation. *The American Economic Review*, 59(2):488–493.

Schön, L. (2000). En modern svensk ekonomisk historia: Tillväxt och omvandling under två sekel. *Lund: Centraltryckeriet AB, Borås*.

Setser, K. (2007). Use of anesthesia increases precision of snake length measurements. *Herpetological Review*, 38(4):409.

Sjoberg, G. (1960). The] preindustrial city: past and present. Technical report.

SKF (1904). Sveriges kommunaltekniska förening, årlig publikation, 1904-1915. Technical report, Stockholm.

Smith, D. S. (1983). Differential mortality in the united states before 1900. *The Journal of interdisciplinary history*, 13(4):735–759.

Smith, J. P. (1999). Healthy bodies and thick wallets: the dual relation between health and economic status. *Journal of Economic perspectives*, 13(2):145–166.

Smith, N. (1979). Toward a Theory of Gentrification A Back to the City Movement by Capital, not People. *Journal of the American Planning Association*, 45(4):538–548. Publisher: Routledge _eprint: https://doi.org/10.1080/01944367908977002.

Smith, N. (2010). *Uneven development: Nature, capital, and the production of space*. University of Georgia Press.

Smith, N. and Williams, P. (2013). *Gentrification of the City*. Routledge.

Soderberg, J., Jonsson, U., and Persson, C. (2003). *A stagnating metropolis: the economy and demography of Stockholm, 1750-1850*, volume 13. Cambridge University Press.

SSS (1897). Hälsovårdsnämndens årsberättelse. *Stockholm Stads Statistiska Kontor, KL Beckmans Boktryckeri*.

SSS (1907). Statistisk Årsbok för Stockholms stad. *Stockholm Stads Statistiska Kontor, KL Beckmans Boktryckeri*.

Sundin, J. (1995). Culture, class, and infant mortality during the Swedish mortality transition, 1750-1850. *Social science history*, 19(1):117–145. Publisher: JSTOR.

Sundin, J. and Willner, S. (2007). *Social change and health in Sweden: 250 years of politics and practice*. Swedish National Institute of Public Health.

Swaan, A. d. (1988). In care of the state: health care, education and welfare in Europe and the USA in the modern era.

Szreter, S. (1988). The Importance of Social Intervention in Britain's Mortality Decline c. 1850? 1914: a Re-interpretation of the Role of Public Health. *Social history of medicine*, 1(1):1–38. Publisher: Oxford University Press Oxford.

Torssander, J. and Erikson, R. (2010). Stratification and mortality—A comparison of education, class, status, and income. *European Sociological Review*, 26(4):465–474. Publisher: Oxford University Press.

Troesken, W. (2001). Race, disease, and the provision of water in American cities, 1889–1921. *The Journal of Economic History*, 61(03):750–776.

Troesken, W. (2002). The limits of Jim Crow: race and the provision of water and sewerage services in American cities, 1880–1925. *The Journal of Economic History*, 62(3):734–772.

Troesken, W. (2004). *Water, race, and disease*. MIT Press.

Van Leeuwen, M. H. and Maas, I. (2011). *HISCLASS: A historical international social class scheme*. Universitaire Pers Leuven.

Van Leeuwen, M. H., Maas, I., and Miles, A. (2002). *HISCO: Historical international standard classification of occupations*. Leuven Univ Pr.

Van Poppel, F., Jennissen, R., and Mandemakers, K. (2009). Time trends in social class mortality differentials in the Netherlands, 1820-1920: An assessment based on indirect estimation techniques. *Social Science History*, pages 119–153. Publisher: JSTOR.

Van Poppel, F. and Van der Heijden, C. (1997). The effects of water supply on infant and childhood mortality: a review of historical evidence. *Health Transition Review*, pages 113–148.

Vance, J. E. (1971). Land assignment in the precapitalist, capitalist, and postcapitalist city. *Economic geography*, 47(2):101–120. Publisher: Taylor & Francis.

Wagner, E. G., Lanoix, J. N., and Organization, W. H. (1958). *Excreta disposal for rural areas and small communities*. World Health Organization.

Winpenny, J. (2005). *Managing water as an economic resource*. Routledge.

Wolke, L. E. (2015). *Stockholms historia under 750 \aar*. Svenska Historiska Media Förlag AB.

Woods, B. (2004). The origins of social class mortality differentials. *P. Boyle, S. Curtis, T. Gatrell, EG Graham & E. Moore (red.), The geography of health inequalities in the developed world*, pages 37–52.

Woods, R. I., Watterson, P. A., and Woodward, J. H. (1988). The causes of rapid infant mortality decline in England and Wales, 1861–1921 Part I. *Population studies*, 42(3):343–366.

Woods, R. I., Watterson, P. A., and Woodward, J. H. (1989). The causes of rapid infant mortality decline in England and Wales, 1861–1921. Part II. *Population studies*, 43(1):113–132. Publisher: Taylor & Francis.

Wretlind, E. W. (1866). *Undersökningar rörande Stockholms Mortalitet: I. Mortaliteten. II. Dödsorsakerna. Akademisk Afhandling*, volume 1. Norstedt.

Zheng, S. and Kahn, M. E. (2013). Does Government Investment in Local Public Goods Spur Gentrification? Evidence from Beijing: Does Government Investment in Local Public Goods Spur Gentrification? *Real Estate Economics*, 41(1):1–28.

Zuk, M., Bierbaum, A. H., Chapple, K., Gorska, K., and Loukaitou-Sideris, A. (2018). Gentrification, displacement, and the role of public investment. *Journal of Planning Literature*, 33(1):31–44. Publisher: SAGE Publications Sage CA: Los Angeles, CA.