Life and Death in the City: Demography and Living Standards during Stockholm's Industrialization

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Life and Death in the City

Demography and living standards during Stockholm's industrialization

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Abstract

This dissertation uses longitudinal micro-data from Stockholm between 1878 and 1926 to study the causes and consequences of the fertility transition and to examine the development of living standards inequality during industrialization. Although both processes have received much interest from researchers, we know relatively little of how either one played out among individuals in urban areas, which were both at the forefront of industrialization and the fertility decline. To address this deficiency, I have analyzed the development of socioeconomic differentials in fertility, children's intergenerational social mobility, and infant and child mortality during Stockholm's industrialization and fertility transition. The results of this work challenge many existing explanations of the fertility decline and reveal how, despite overall improvements in living standards, elite socioeconomic groups were able to continually leverage their superior resources to maintain significantly lower levels of infant and child mortality.

Key words: fertility transition, industrialization, urbanization, socioeconomic status, living standards

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Brüder weit weg waren, habe ich mich aufgrund eurer Großzügigkeit und Offenheit nie familienlos in Europa gefühlt.

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Contents

Introduction

Motivation and Aim

Demography and living standards, in their broadest sense, are inextricably linked to one another. Populations both actively and passively anticipate and respond to changes in economic conditions, sanitary environments, institutional arrangements, and social currents. In turn, the changes exhibited in populations can influence how living standards themselves evolve through, for example, changes in sex ratios, age structures, or marriage patterns. This relationship is not just a relic of the Malthusian world, but is still present today, evidenced by the significant declines in fertility that occurred as a result of the Great Recession (Goldstein, Kreyenfeld, Jasilioniene, & Örsal, 2013). It is because of this fundamental interplay that demographic data are so valuable for economic and social research, as they allow researchers to move beyond the mere description of population trends and enable the evaluation of their underlying determinants.

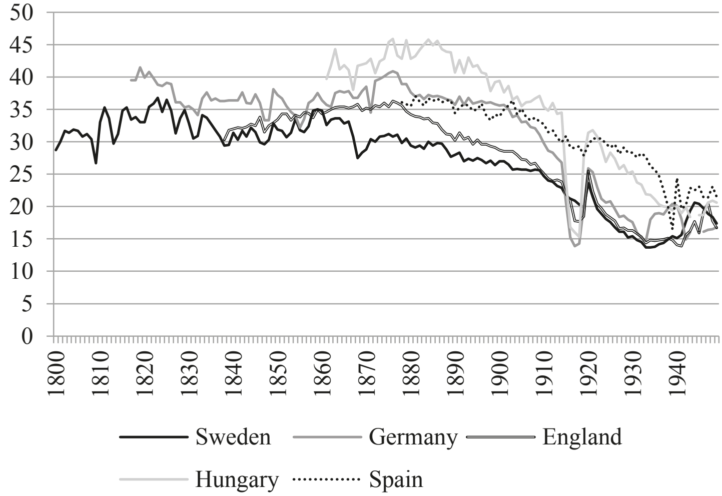
Using a historical population register for Stockholm, Sweden, this dissertation exploits the relationship between demography and living standards in order to deepen our understanding of two major topics of economic history: the causes of the fertility transition and the effects of industrialization on living standards inequality. Both of these have received much attention in historical research, but continue to be heavily debated. With regard to the fertility decline, there remains disagreement about the relative importance of economic, social, technological, or demographic factors in leading to lower fertility (Guinnane, 2011; van de Kaa, 1996). Part of the reason for this lack of consensus is that few studies have analyzed an urban fertility transition from an individual perspective, when there is evidence suggesting that urban populations were geographic forerunners of the decline (see Knodel, 1974; Mosk, 1980; Sharlin, 1986). As for the distributional effects of industrialization, it is yet unresolved whether the economic growth experienced during that process reduced or exacerbated living standards inequality (see e.g., Feinstein, 1998; Hobsbawm, 1957; Lindert & Williamson, 1983; Mokyr, 1988). This has been partially a result of disagreement as to how one should best measure living standards, but also is due to the fact that most studies of the topic have either relied on aggregated data series or had ambiguous external validity. This dissertation will contribute to these discussions by analyzing individual-level data for a large European capital to examine the development of socioeconomic heterogeneity in fertility and mortality during industrialization and the fertility transition.

Previous Research

The Fertility Transition and its Causes

The fertility transition remains one of the major puzzles of economic history and historical demography. After centuries of high fertility, birth rates began to fall in many populations between 1870 and 1930. Some populations saw decreases in fertility even earlier than this period, notably in France and the United States, but the large majority only entered their respective fertility transitions after 1870 (see Coale & Treadway, 1984, p. 38). Within half a century, crude birth rates across Europe were often reduced by a factor of two or more. In Sweden, for instance, crude birth rates consistently fluctuated between 30 and 35 per 1,000 population during the eighteenth and nineteenth centuries. After the Swedish fertility transition began in the 1870s, crude birth rates fell to less than 15 per 1,000 by 1930. Sweden was hardly exceptional in this regard. Figure 1 shows the fertility decline (in crude birth rates) for five European countries. Despite many differences between each of these populations, fertility began to decline in all of them more or less simultaneously and reached roughly the same level by 1950. The simultaneity of the decline throughout the continent is perplexing, as there was extreme heterogeneity in terms of the economic, social, demographic, and institutional conditions under which fertility decreased. As a result, a multitude of explanations for the fertility transition have been put forward.

Figure 1. Crude birth rate per 1,000 population in selected European countries, 1800-1950.



Notes: The crude birth rate is defined as the number of births divided by the total population of a country in a given year.

Source: Palgrave Macmillan Ltd . (April 2013). *International Historical Statistics*.

Carlsson (1966) argued that explanations for the fertility decline generally fall into two categories: adjustment explanations and innovation-diffusion explanations. Adjustment explanations argue that fertility falls as the economic, social, and demographic conditions under which a given level of contraception is practiced change. Innovation-diffusion hypotheses, on the other hand, argue that as new ideas, norms, or technologies spread throughout a society, individuals may become more willing or more able to control their fertility. It should be recognized that these hypotheses are not diametrically opposed to one another, and in fact may be complementary (see Cleland, 2001), but they do emphasize different mechanisms in explaining why widespread fertility limitation emerged.

The majority of explanations of the fertility transition are of the adjustment type. How they differ from one another primarily stems from where they presuppose the causal link between fertility and certain contextual changes lies. Below, I will primarily discuss how fertility adjustment is thought to occur with regard to changes in demographic and economic conditions.

The classical demographic adjustment explanation argues that the decline of mortality, especially among children, brought about a decline in fertility via a combination of physiological and microeconomic mechanisms (e.g. Notestein, 1953). From the physiological viewpoint, a decline of infant mortality will reduce a mother's exposure to pregnancy by increasing her lifetime duration of lactational infecundability. Thus, a decline in mortality will simply shift the average exposure to pregnancy and births, thereby lowering fertility.

Improvements in child survival could also reduce fertility, however, by altering parents' demand for births. The hoarding hypothesis argues that when mortality is high parents will have more children than they actually desire in order to offset probable losses. When survival prospects improve and uncertainty is reduced, couples will lower their fertility. The child replacement hypothesis, on the other hand, suggests that parents are reactive rather than proactive in satisfying their demand for children and intentionally replace those who have died. As mortality subsides, this replacement will be unnecessary and total fertility will fall. Although evidence supporting the causal role of falling mortality in the fertility decline has been presented in various populations (Haines, 1998b; Reher, 1999; Reher & Sanz-Gimeno, 2007; van Poppel, Reher, Sanz-Gimeno, Sanchez-Dominguez, & Beekink, 2012) and the mechanisms linking mortality and fertility are intuitive, they have been dismissed for a number of reasons. The most cited arguments against the importance of mortality decline as a precursor to fertility decline come from the European Fertility Project (Coale & Watkins, 1986). There it was shown that in many European provinces fertility decline actually preceded reductions in infant mortality (van de Walle, 1986). But timing is not the only problematic issue here. Some studies have shown that, although infant and child mortality were high in the past, it was concentrated in a relatively small proportion of families, which calls into question the extent to which most couples would have calculated future losses or had to replace lost children (Edvinsson, Brändström, Rogers, & Broström, 2005; Edvinsson & Janssens, 2012). The causal role of mortality decline in stimulating the fertility decline is further called into question by the fact that the fertility decline not only saw a reduction of gross fertility (i.e. the total number of births per woman) but also net fertility (i.e. the number of surviving children per woman) (Clark & Cummins, 2015; Doepke, 2005), implying that there may have been a change in parents' demand for children and not just their demand for births.

The fertility transition has also long been hypothesized to have been a result of economic developments that lowered the parental demand for children (see Dumont, 1890; Notestein, 1953). This is because the onset of the fertility transition occurred almost simultaneously with significant economic changes, like increases in real wages, industrialization, and rising costs of raising children. Eventually, these hypotheses were adopted by economists and formalized into testable predictions (see Barro & Becker, 1989; Becker, 1960; Becker & Lewis, 1973; Becker & Tomes, 1976; Easterlin, 1975; Leibenstein, 1974, 1975).

Becker (1960) famously employed a consumer-choice framework to establish the link between economic changes and fertility. He argued that, within a constrained household budget, parents will strive to maximize the amount of satisfaction they can derive from a combination of market goods and children. Parents' demand for children is assumed to be positively related to total household income, and may be satisfied either by having greater numbers of children of a lower quality (i.e. low levels of investment) or fewer children of a higher quality. At the same time, because children require a significant time investment, higher levels of labor income, particularly for women, will incur a greater opportunity cost per child. As a result, economic changes that lead to decreases in the price of child quality relative to child quantity will lead parents to invest more in each child and therefore reduce fertility.

How successful these changes are in explaining the fertility decline is not yet resolved (Guinnane, 2011). Part of this lies in the fact that many economic indicators are inadequate, incomplete, or unavailable, especially at the individual level, during the period in question. For example, data on female labor force participation prior to the twentieth century are difficult to come by aside from specific industries (e.g., Horrell & Humphries, 1995), and available information on female employment almost certainly understates the extent to which women actually worked in the formal economy. In Sweden, official statistics indicate that by 1920, only 4% of married women were formally employed (Silenstam, 1970), and recent estimates of female labor force participation for all women indicate that, in 1870, only about 19% of women had a formal occupation; this figure remained more or less constant until the 1920s, long after Sweden's fertility transition had begun (Stanfors, 2014). In the Netherlands, there is even some evidence suggesting that female labor force participation among married women was actually declining during the Dutch fertility transition (van Poppel, van Dalen, & Walhout, 2009). Because of the data quality issues associated with women's work in this period, it is therefore difficult to discern its importance in the fertility transition and empirical work on the topic has produced mixed results (see Brown & Guinnane, 2002; Galloway, Hammel, & Lee, 1994; Janssens, 2014; Schultz, 1985).

The relative price of child quality, and thus the demand for children, may have also fallen as a consequence of urbanization. This would explain, for instance, why urban areas were often leaders in the fertility transition and generally had lower fertility rates than the countryside (see e.g., Dribe, 2009; Knodel, 1974; Mosk, 1980; Sharlin, 1986). A common explanation for this relationship is that children's economic contribution to their families was smaller in urban areas as a result of increasing mechanization and the expansion of mandatory education, which together depressed parents' demand for child quantity. Indeed, there is evidence from the United States supporting the idea that exogenous increases in the price of children may have fertility-reducing effects (Wanamaker, 2014). But recent work on Britain using working-class autobiographies has revealed that the children born in the early years of the fertility decline were entering the labor market at younger ages than previous cohorts. Furthermore, those of factory workers tended to enter the labor force even earlier than those of farmers (Humphries, 2010, p. 205). As for the expansion of education, Sweden passed a law in 1842 that required all municipalities to have a school, and by the 1860s over 95% of all children aged 7-14 were enrolled in some formal education (Statistics Sweden, 1974). Despite such a massive expansion of primary education, urban total marital fertility rates did not begin to decrease until the 1880s, while in rural areas there was no sign of decline until as late as the twentieth century (Dribe, 2009). The importance of urbanization as a cause of the fertility transition is further complicated by the fact that many populations entered the fertility decline before any significant urban growth occurred, most notably France.

As a complement to the abovementioned adjustment explanations, some have attempted to explain the historical fertility transition as a result of a diffusion of innovations (see e.g., Cleland & Wilson, 1987). Such explanations come in a variety of forms, but here I will mainly discuss the diffusion of two types of innovations: norms/ideas and technologies. In both cases, it is assumed that certain members of society are more greatly exposed to and likely to adopt innovations before the general population. Such individuals are typically characterized as having a high socioeconomic status, wide social networks, being open to deviance, and more actively seeking new information compared to later adopters (E. M. Rogers, 2003). In order for innovations to be adopted by the masses, they must be perceived as advantageous, compatible with norms, relatively simply to use, and generally be observable (Cleland, 2001). The mechanisms through which they will diffuse include interpersonal communication, observation, and changes in the normative context.

The role of normative change as a causal force for fertility decline is certainly appealing. In Ansley Coale's (1973) "ready, willing, and able" framework, he lists as one of the preconditions to fertility decline that fertility must be viewed as part of the 'calculus of conscious choice'. That is, if reproduction is perceived as a moral obligation, a communal good, or in the hands of the divine, this will restrict women's willingness to limit their fertility. Changing attitudes towards regulating fertility would be able to explain, for instance, why fertility declined under such a wide array of economic conditions. In line with this perspective, much attention has been paid to the role of increasing secularization during European fertility declines (see e.g., Derosas & van Poppel, 2006; Lesthaeghe, 1977, 1980, 1983) and for good reason. There were consistent religious differences in fertility within historical populations based on differences in pro-natalist philosophies and the reinforcement of marriage patterns and gender roles (see Brown & Guinnane, 2002; Dribe, 2009; Hacker, 1999; Lesthaeghe & Surkyn, 1988). However, the importance of increasing secularization in leading to the fertility decline may have been secondary to socioeconomic forces. Analyses of denominational fertility differentials during the transition have generally shown that individual reproduction was much more strongly influenced by factors such as socioeconomic status or living in an urban environment than one's religious affiliation (Derosas, 2006; Kok & van Bavel, 2006; Schellekens & van Poppel, 2006).

Some diffusion explanations place more emphasis on the spread of contraceptive technologies, as opposed to ideas. A diffusion of new technologies would explain why, after centuries of high birth rates, fertility would suddenly and rapidly fall. Unfortunately, data on contraceptive uptake is hard to come by for historical populations. Anecdotal evidence suggests that many working-class mothers were unsure of how to effectively limit their fertility (Seccombe, 1990) and the widespread introduction of anticontraceptive legislation throughout Europe and North America does suggest that contraceptive uptake was becoming increasingly common, or at least it was perceived to be. In the United States, the Comstock Laws effectively banned contraceptives in 1873. In England in 1877, the Bredlaugh-Besant trial publicly shamed promoters of literature on sexuality and contraception. The German *Lex Heinze* was passed in 1900 and essentially criminalized the distribution of contraceptive literature; a nearly identical law, *Lex Hinke*, was passed in Sweden in 1910. This fragmentary evidence suggests that the prevalence of new contraceptive technologies may have been increasing during the relevant era, but a paucity of data on the subject makes it difficult disentangle its role in the fertility decline.

Whether or not the introduction of new contraceptive technologies was an important factor in the fertility transition remains a contentious issue, however. There is some compelling evidence supporting the notion that contraceptive techniques have long been known (McLaren, 1992; van de Walle & Muhsam, 1995; van de Walle, 2000). Santow (1995) showed that the preoccupation of medieval clergy and the euphemistic language of historical Europeans clearly points to the knowledge and practicing of coitus interruptus prior to the demographic transition. In recent years, evidence from micro-analyses has also shown that pre-transitional populations were fairly efficient in reducing their fertility, at least in the short term (Amialchuk & Dimitrova, 2012; Bengtsson & Dribe, 2006; Brown & Guinnane, 2002; Dribe & Scalone, 2010; van Bavel, 2004a). Some research also suggests that traditional methods, like abstinence or withdrawal, remained the main forms of contraception practiced during the fertility transition (David & Sanderson, 1986; Fisher, 2006). Taken together, this evidence calls into question the importance of the introduction of new contraceptive techniques in initiating the fertility decline.

All of the adjustment and diffusion explanations listed above have evidence both supporting and contradicting their validity, but what is lacking from the large majority of historical fertility studies is an individual perspective. Virtually all theories of the fertility decline are concerned with human agency, yet much of the empirical research concerning its causes has been conducted at higher levels of aggregation. Because of the extensive simultaneity of demographic, social, and economic changes during the period of interest, aggregate analyses of the transition can do little to distinguish the relative importance of any of the proposed explanations. Studies that have taken a micro perspective on the topic have revealed some details that may be crucial to understanding why fertility fell. For example, a growing body of evidence has shown that fertility decline generally began among the socioeconomic elite in rural areas (see Clark & Cummins, 2015; Dribe, Oris & Pozzi, 2014). Such a socioeconomic pattern per se cannot tell us the decline's exact causes, but it can offer some insight as to which explanations are more or less likely to predominate. This is because proposed explanations of the overall decline, like changes in access to contraception, mortality, women's employment, and religiosity, all would have disproportionately impacted some groups over others, suggesting that different groups were faced with more or less pressure to limit their fertility depending on where such pressure originated. We have little evidence, however, of whether or not the experience of the countryside was the same for urban residents, who may have been exposed to a rather different incentive structure regarding their fertility due to differences in, for example, children's educational opportunities, mortality, and marriage patterns. Understanding the socioeconomic patterns of the decline would be especially valuable in the context of the Swedish transition, as it has been shown that urban areas tended to enter the fertility decline several decades before rural areas (Dribe 2009). This dissertation will therefore contribute to the literature by using individual-level data to study socioeconomic heterogeneity in fertility and children's outcomes in Stockholm, both of which can suggest which explanations are consistent with observed patterns.

Living Standards Inequality and Industrialization

The study of how inequality in living standards evolved during industrialization has been impaired by a different set of problems than research into the causes of the fertility decline. In the case of the latter, researchers have a well-defined outcome that requires explanation, i.e. falling fertility. In order to study the development of living standards inequality, however, we must first have an adequate measure of living standards. This has proven to be a challenging task for economic historians, primarily because of the disagreement as to which proxies best capture living standards, a result of an ambiguous concept (Sen, 1984).

Empirical analysis of the concept has generally been focused either on inputs or outputs of living standards (Haines & Ferrie, 2011). Traditionally, living standards have been treated as equivalent to real wages or income per capita, and even though such a relationship is overly simplistic, it is not unreasonable to say that these measures capture important inputs. Unfortunately, such proxies do not measure the outcomes associated with them, which are inherently the interest of any researcher hoping to identify changes in living standards. What these traditional indicators instead represent are *potential* outcomes. That is, it is assumed that higher real wages will be used to purchase better food, more comfortable housing, or more luxury goods, but they do not actually identify these patterns and, in reality, increases in purchasing power may not always be equivalent to increases in consumption. This was made clear by Mokyr (1988), who showed that the consumption of luxury goods like tobacco, sugar, and tea did not increase during British industrialization despite simultaneous increases in real wages (Lindert & Williamson, 1983). In response to this shortcoming, many scholars have turned to alternative indicators (see Allen, Bengtsson, & Dribe, 2005; Bengtsson, Campbell, & Lee, 2004), which identify changing living standards from the perspective of outputs. Both anthropometric and demographic indicators, such as heights and child mortality (see Sen, 1998; Steckel, 1995), are valuable data sources to this end as they present outcomes resulting from an accumulation of many inputs to living standards, such as economic security, exposure to disease, the presence of child labor, and urban crowding, among others. They differ, however, in that height data is typically only available for highly selected groups of individuals in a population, such as soldiers or convicts, who are almost certainly not representative of the general population. Furthermore, studies using military records generally exclude half of the story, women, when it has been shown that trends in male and female heights can move independently from one another, thus providing different assessments of the development of living standards (Carson, 2011). Historical mortality data, on the other hand, can often be found for whole populations, or at least substantial parts of it. As a result of these different approaches, there have been various interpretations of just how inequality in living standards evolved during industrialization.

The development of income and wealth inequality has been of major interest in this debate. Kuznets (1955) famously hypothesized that the process of economic growth should cause income inequality to first increase during the transition from a pre-industrial to an industrial economy, followed by a period of stagnation, and eventually decline. This view has only received mixed support for British case, which has overwhelmingly received the most attention from scholars. Studies of long-run trends have found decreases in income inequality since the early modern period, but that this process largely accelerated after the turn of the twentieth century (Jackson, 1994; Soltow, 1968). A later British study showed that earnings inequality increased during the early decades of industrialization until the middle of the nineteenth century, only to decline slightly near the turn of the twentieth century (Williamson, 1980). In contrast to these findings, Feinstein (1988) showed that income inequality remained more or less constant throughout the nineteenth and early twentieth centuries. In Sweden, recent work on long-run wealth inequality has shown that that wealth became more concentrated at the top of the distribution throughout industrialization and only began to decline in the 1910s (Roine & Waldenström, 2009). For France, similar trends have been observed (see Piketty, Postel-Vinay, & Rosenthal, 2006). Northern Ireland saw no such increases in wealth inequality during industrialization. Instead, there was a more or less continuous decline since the middle of the nineteenth century (Turner, 2010). The body of historical research on income and wealth inequality has thus provided us with few conclusive findings with regard to the development of living standards inequality during industrialization.

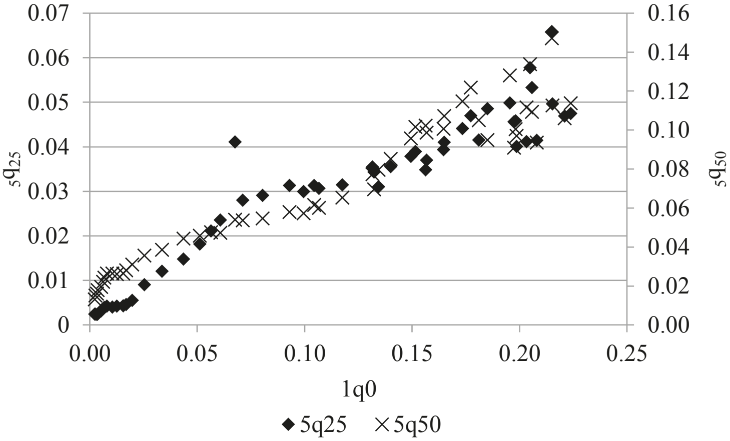
Turning to output-oriented measures of living standards, the development of heights and their socioeconomic distribution during industrialization has offered a radically different view than the one suggested by traditional economic proxies. While real wages were increasing throughout Western Europe, heights were often declining. In Stockholm, for instance, heights of military recruits decreased during the first half of the nineteenth century (Sandberg & Steckel, 1988), yet it was precisely during this period when real wages reversed their downward trend and had begun to rise (Söderberg, 1987). In the United Kingdom, Germany, and the United States, stature appears to have decreased or stagnated until the mid to late nineteenth century (Ewert, 2006; Komlos, 1993; Zehetmayer, 2013). It was generally only at later stages of industrial development that heights began to increase again, and it is for this reason that it has been argued that traditional living standards indicators may have overstated the role of industrialization in improving living conditions (Komlos, 1993).

Even though heights eventually rebounded and increased following the onset of industrialization, there is conflicting evidence as to how equitable this process was. For the United States, Germany, and Spain, there is evidence that class differences in stature only emerged for individuals born during industrialization and widened over time (Ayuda & Puche-Gil, 2014;

Ewert, 2006; Latzsch & Schuster, 2009; Margo & Steckel, 1983; Sokoloff & Villaflor, 1982; Sunder, 2013). In other countries, socioeconomic height differentials were already rather large near the beginning of industrialization but declined slowly thereafter (Alter, Neven, & Oris, 2004b ; Floud, Wachter, & Gregory, 1990, pp. 196-198; Öberg, 2014). Although the anthropometric literature has not yet arrived at a consensus as to how industrialization influenced living standards inequality, it has revealed the importance of considering living standards in terms of outputs, which may not always follow the trends of traditional economic indicators. To their detriment, however, anthropometric studies often suffer from issues of external validity due to the highly selected nature of the data.

Demographic measures of living standards, particularly mortality at young ages, differ from the abovementioned indicators in important ways that make them extremely valuable. First, demographic data are more commonly available for entire populations, both males and females. Even when demographic records are incomplete, they invariably represent a larger share of the population than other indicators. Second, childhood survival may be viewed as the primal indicator of living standards. Individual purchasing power or heights in adulthood are always conditional on surviving past the first years of life. Finally, the level of mortality at young ages is a strong predictor of mortality experiences of the population in general, as seen below in figure 2. Using data for Sweden between 1751 and 2011 for both men and women, I have plotted the probability of dying for the age groups 25-29 and 50-54 against the probability of dying before age 1. The figure makes it clear how strongly mortality at young ages reflects trends in adult mortality as well. As such, by using childhood survival as an indicator of living standards, we can also approximate the living conditions of the general population.

Figure 2. Probability of dying in the age groups 25-29 (${}_5q_{25}$) and 50-54 (${}_5q_{50}$) by the probability of dying before age 1 (${}_1q_0$) for Sweden between 1751 and 2011.



Notes: Numbers derived from period life tables for Sweden for five-year periods.

Source: Human Mortality Database.

When we view the development of living standards through the prism of demography, we arrive at many of the same conclusions produced by the anthropometric literature. In the midst of real wage increases there was generally a worsening of mortality conditions as a greater share of the populations moved into cities. This pattern is well-documented among historical populations in Europe and North America (see Armstrong, 1981; Bourgeois-Pichat, 1965; Fridlizius, 1988; Haines, 1998a; Szreter & Mooney, 1998; Turpeinen, 1988). Just as declining heights signified worsening living standards so too did stalling mortality transitions throughout the industrializing world. Furthermore, cross-sectional studies of socioeconomic differences in mortality at young ages have found large class differences both before and during industrialization (see e.g., Bengtsson & Dribe, 2010; Haines, 1985, 1989; Preston & Haines, 1991). Evidence suggests urban areas, in particular, tended to exhibit more socioeconomic inequality in child mortality than rural areas (Edvinsson, 2004; Garret, Reid, Schürer, & Szreter, 2001, p. 155; Smith, 1983), likely due to a greater importance of personal resources for accessing basic health infrastructure in exceptionally harsh epidemiological environments (Link & Phelan, 1995). Few studies have actually documented how these differences changed over time, however, making it difficult to evaluate just how industrialization influenced living standards inequality. Using a variety of data sources, Antonovsky and Bernstein (1977) showed that despite declines in infant mortality across all socioeconomic groups relative class differences remained unchanged. This finding was reiterated for England and Wales with higher quality data, where relative socioeconomic differences in infant mortality largely persisted between 1890 and 1911 (Haines, 1995). Other studies have come to different conclusions. In Geneva, social differences in mortality have been slowly narrowing since the pre-industrial period (Schumacher & Oris, 2011). In the Netherlands, Sweden, and Germany, there is evidence that prior to the mortality decline there were no socioeconomic differences in infant mortality. It was only during the most rapid stages of decline that a class gradient emerged, which was again closed as the transition matured (Edvinsson, 2004; Lee & Marschalck, 2002; Sundin, 1995; van Poppel, Jonker, & Mandemakers, 2005).

Apart from simply studying differences in levels of mortality to measure living standards inequality, some scholars have combined demographic and economic data to evaluate the distribution of living standards in terms of populations' short-term economic security (Bengtsson, Campbell & Lee, 2004). Specifically, this indicator defines low living standards not just by the level of mortality but as the existence of a demographic response to short-term fluctuations in prices or wages. It therefore makes use of both living standards inputs and outputs to evaluate living conditions. If a population were in such a precarious position that a small change in, say, food prices could lead to increases in mortality, they could be said to have a low standard of living. This is because such a response would be indicative of an inability to smooth consumption, lack of access to credit, and limited savings (Bengtsson, 2004, p. 35). In turn, identifying differences in this response based on one's class would provide evidence of unequal living standards in a population. Using this approach, studies of rural populations have found that mortality, particularly of low status individuals, continued to be influenced by short-term economic variation until the mid-nineteenth century, after which the response disappeared and differences between classes decreased (Alter, Neven & Oris, 2004a; Bengtsson & Dribe, 2005). Few studies of urban areas have looked at living standards in this way, but there is some evidence suggesting that urban child mortality continued to respond to short-term economic change as late as 1935 (Cagigal & Houpt, 2011).

There is much conflicting evidence regarding the development of living standards inequality during industrialization. Demographic and anthropometric evidence tend to arrive at similar conclusions and present a rather different view of this process than many economic indicators. Nevertheless, there remains a lack of consensus on the issue even among studies using the same sets of indicators. While this dissertation cannot definitively determine if industrialization, in general, was an equitable process, it can contribute to this debate by analyzing absolute and relative socioeconomic differentials in infant and child mortality using individual-level data for Sweden's largest city. In addition, it will further contribute to the discussion by constructing new cost of living and wage series, estimating class-specific mortality responses to economic variation in an urban area, and by analyzing individual-level cause-specific mortality. By approaching this question from multiple perspectives, the present work will provide new evidence on the distributional effects of industrialization in Stockholm and, more importantly, the urban world of the time.

Context

Stockholm's Industrial and Urban Growth

The present work is set in Sweden's capital and largest city, Stockholm. Founded in the first half of the thirteenth century, the city is positioned directly east of Lake Mälaren and west of the Baltic Sea on the Stockholm archipelago in central Sweden. The city's geographic proximity to water has played an important part in its development and history, providing it with natural defenses as well as direct trading routes to port towns in the Baltic region and beyond. Already from its founding, Stockholm was a city of migrants and commerce. During the late medieval period, German merchants were among the city's earliest inhabitants and trade with Hanseatic ports, such as Danzig, Lübeck, and Hamburg, brought an influx of wealth, goods, ideas, and people to the city (Ericson Wolke, 2001). Stockholm's dominant role in international trade relative to other Swedish ports remained largely unchallenged until the nineteenth century, when Gothenburg became a major domestic rival, particularly in terms of transoceanic commerce. But as

Stockholm's competitive advantage in exporting declined, its geographic location became increasingly significant to its industrial development, as it continued to serve as the nation's main entry point for innovation and immigration.

The early phases of industrial growth in Sweden were largely concentrated in the capital. Between 1750 and 1830, nearly half of the entire country's factory labor force was located in Stockholm, most of which was involved in textile manufacturing (Söderberg, Jonsson, & Persson, 1991). After 1830, however, the share of Swedish industry in the city declined drastically, so that, by 1850, only about 20% of the country's factory workers were located there. It was only in the second half of the nineteenth century, that the bulk of Stockholm's industrial growth occurred. Despite growing opportunities in the rest of the country, Stockholm's economy continued to be defined by manufacturing until after the turn of the twentieth century. In 1900, over half of all workers in Stockholm were in the industrial sector (see table 1). For men, the greatest opportunities for work were in metalwork, painting, carpentry, and shoemaking. The industrial jobs available for women were rather different. Their best chances of finding work outside of domestic service were in the textile and tobacco industries (Stockholm Stads Statistiska Kontor, 1905, pp. 58-66). But as the first decades of the twentieth century wore on an increasing proportion of the labor force became involved in trade and commerce; by 1930, the share of the working population in manufacturing and trade were nearly equal.

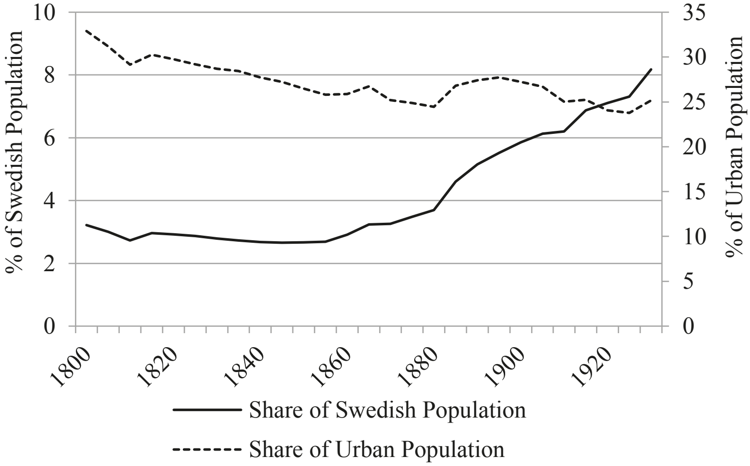
Table 1. Share of labor force in various sectors in Stockholm between 1900 and 1930.

Share of Whole Population:	1900	1910	1920	1930
Agriculture	0.5	0.5	0.8	1.0
Manufacturing and Mining	37.2	38.1	38.0	40.1
Trade and Commerce	21.6	24.7	31.2	36.1
Public Service	11.8	11.4	12.3	12.5
Unemployed/No information	28.9	25.4	17.8	10.3
Share of Workers by Sector:	**1900**	**1910**	**1920**	**1930**
Agriculture	0.6	0.6	1.0	1.1
Manufacturing and Mining	52.3	51.0	46.2	44.6
Trade and Commerce	30.4	33.1	37.9	40.3
Public Service	16.6	15.2	14.9	14.0

Source: Shares have been calculated from aggregate numbers of workers in each sector reported in *Statistisk Årsbok för Stockholms Stad* published in the years 1906 (pp.58-65), 1914 (pp.72-77), 1925 (pp.18-22), and 1934 (p.22).

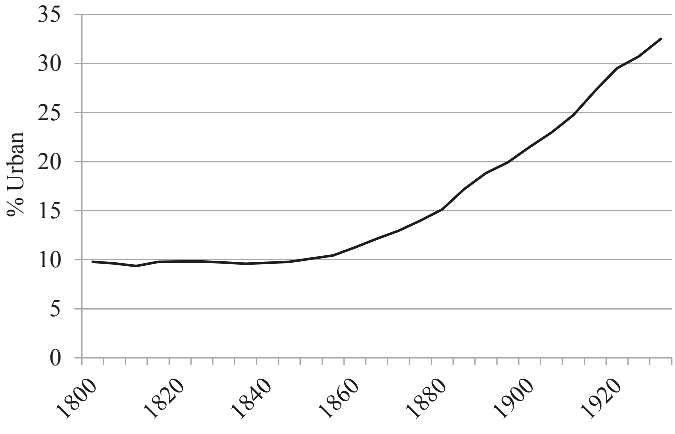
That the city was the cradle of Swedish industrialization is no coincidence, as throughout its history it has been Sweden's largest urban area and therefore the country's most concentrated pool of human resources. In 1800, Stockholm accounted for over 3% of Sweden's population and one-third of the urban population (see figure 3). As the nineteenth century progressed, ever-greater numbers of people flocked to the capital, causing Stockholm's population to make up an increasingly large proportion of the Swedish population. By 1930, the city proper housed over half a million people, 8% of Sweden's inhabitants.

Figure 3. Stockholm's population as a share of the total Swedish population and total urban population.



Source: Numbers for Stockholm taken from *Statistisk Årsbok för Stockholms Stad 1930*, p. 6. For Sweden and urban populations, numbers taken from *Historisk Statistik för Sverige, Del 1. Befolkning*, pp. 45-47.

Figure 4. Share of Swedish population living in urban areas 1800-1930.



Source: Shares taken from Historisk Statistik för Sverige, Del 1. Befolkning, pp. 45-47.

Most of the country's urbanization did not occur until the second half of the nineteenth century. Prior to 1860, no more than 10% of the Swedish population lived in urban areas (see figure 4). But over the next 70 years this figure increased substantially and, by 1930, nearly one-third of all Swedes resided in cities. The growth of Stockholm and other urban areas was enabled by falling transportation costs due to the expansion of the national railroad network. In 1862, the capital was connected by rail to the nation's second largest city, Gothenburg, and two years later to the third largest, Malmö, in southern Sweden. Connecting cities over such a large distance allowed smaller municipalities to link to the main networks thereby facilitating domestic migration. The expansion of the railroad network was coincident with a rising wage premium for industrial work compared to agriculture in the 1860s in Stockholm (Lundh, Schön, & Svensson, 2004, p. 80), making rural-urban migration an increasingly attractive option for many young people. As a result, migrants from rural areas began to flood the cities in the latter half of the nineteenth century. It has been estimated that 50% of the urban growth in Sweden that took place during these decades is attributable to the expansion of rail networks (Berger & Enflo, 2013). As the city became more densely populated, urban sprawl took hold in the early twentieth century and the city expanded geographically to the southwest, eventually amalgamating two suburbs, Bromma and Brännkryka. Urban sprawl continued throughout the twentieth century, and, as of 2014, Stockholm City proper accounted for over 9% of the Swedish population and the Stockholm Metropolitan Area (defined by Statistics Sweden as equivalent to Stockholm County) made up more than 22%.

Socioeconomic Inequality in the Capital

As migrants arrived in Stockholm during the great wave of urbanization, they would have quickly encountered the multitude of problems facing the city. There was a severe shortage of housing which created problems of urban crowding. The average number of people per apartment in 1900 was slightly more than four, and most of the available apartments in the city only had one or two bedrooms, if any at all (some 'apartments' only consisted of a kitchen). According to official reports, nearly 50% of one-room apartments were designated as over-crowded in 1900. A decade later, however, crowding had been somewhat alleviated, as only about 30% of the same apartments were given this designation in 1910 (Stockholm Stads Statistiska Kontor, 1912, p. 29). The issue of housing standards sharply divided the city along geographic and class lines and it was reflective of many of the capital's underlying social problems. The exterior of the inner city had particularly become a refuge for slum housing as the city grew. The working-class districts of Södermalm and Kungholmen were notorious for having cheap rents and small, crowded tenements, leading to a clustering of poverty in these areas. In the first decades of the twentieth century, over 55% of the city's recipients of poverty assistance resided in these two districts and nearly 15% of the population in these areas was being supported by welfare (Stockholm Stads Statistiska Kontor, 1905). The threat of poverty reinforced the demand for affordable housing, allowing the persistence of many small, low-quality abodes. Official reports for 1910 show that over 90% of the available housing in these areas consisted of small apartments (one to three rooms and a kitchen) compared to less than 60% in more affluent parts of the city (Stockholm Stads Statistiska Kontor, 1912).

The disproportionate crowding in low-income areas around the turn of the century also led to a more hostile disease environment, which was buttressed by a lack of sanitation infrastructure; the most crowded districts only gained access to sewers and piped water decades after their wealthier neighbors (Hansen, 1897). Geographic inequality in Stockholm reflected the overarching issue of socioeconomic inequality, which had tangible effects on individual outcomes regardless of where individuals lived in the city.

Stockholm's putrid hygienic conditions led to infant mortality rates of over 300 per 1,000 live births until around the late-1860s (Nelson & Rogers, 1995). But these were hardly equally distributed across social strata. By the 1880s, the children of the unskilled working class had mortality rates up to three times higher than those of the wealthy (Burström, Macassa, Öberg, Bernhardt, & Smedman, 2005). In turn, disproportionate child mortality partially led to vastly different fertility behavior between classes. Women in the lowest classes had fertility rates more than 50% higher than those of the elite in the 1880s, and they remained so throughout much of the period. The significance of socioeconomic differentials in mortality and fertility is that they reflect so many other dimensions of inequality, such as in education, wealth, and opportunity. This work will therefore use socioeconomic differences in demography as a lens through which to examine the evolution of greater developmental inequalities during a period of rapid industrial and urban growth.

Data

The Roteman Database

All papers in this dissertation utilize data from the Roteman Database, which is maintained by the Stockholm City Archives. The Roteman Database is a historical population register that was maintained by the municipal government between 1878 and 1926. It contains all individuals ever living and registered in Stockholm within that time frame. Digitization of the database has been ongoing since the 1970s and currently it contains about 5.7 million records. The main extract used in this dissertation was based on all women in reproductive ages (15 to 49) who were ever present in the city and all individuals connected to them (e.g., husband, family members, children, lodgers), which amounted to 3.7 million records of nearly one million individuals. The data used in this study do not cover the entire population of Stockholm, as some districts are still being digitized, but includes approximately over 70% of the original source material.

Originally, the Roteman System was established to relieve the burden of demographic record keeping from local parish priests, who were becoming overwhelmed by the administrative demands of Stockholm's rapidly growing population as well as by the high volume of intra-urban migration. On November 10, 1876, a government ordinance established the Roteman Institution and the *Mantalsnämnden*, the local board overseeing population and taxation records. It was decided that on January 1, 1878 the Roteman Institution would assume responsibility for all population record keeping, including annual census registration (Geschwind & Fogelvik, 2000). This was done by dividing the city into 16 districts (*rotar)* of approximately 10,000 inhabitants, each of which would be under the purview of a district administrator (*roteman*). Initially, the administrative districts simply took on the traditional parish borders that had long been used by priests to maintain their records; as a result, most of them continued to be called by the same name as the parish within which they fell (e.g., Klara, Jakob, Storkyrkan). As the city became more densely populated and as urban sprawl led to its merging with adjacent suburbs, the number of districts multiplied. On Östermalm, for example, there were originally five registration areas in 1880; by 1924, they had increased to 12. The suburbs of Brännkyrka and Bromma were not even considered a part of Stockholm at the start of the Roteman

System, but were later amalgamated into the city in 1913 and 1916 respectively. By the time the Roteman Institution was disbanded the number of districts had grown to 36, some of which were so densely populated that they only comprised a few city blocks.

The administrators had multiple responsibilities beyond maintaining the district registers, but they were primarily responsible for keeping track of all births, deaths, and migration within and away from the city. This was accomplished by the system's organizational structure, which followed pieces of real estate over time rather than individuals per se. Each property had its own ledger that recorded all its inhabitants and was updated whenever an individual moved in or out, or when someone was born or died. To maintain the quality of the records, all individuals above age 15 were provided with a certificate from their administrator or, if they were migrants, from their parish priest, which they would have to show to a district administrator upon moving to a new registration area (Geschwind & Fogelvik, 2000). When an individual became a resident of that district, the administrator would enter the person's information into the ledger and keep the certificate until they moved out of their district. Avoiding detection under the Roteman System was therefore difficult, as ledgers were updated annually upon census registration. Together these measures led to high-quality longitudinal records for both households and individuals. The longitudinal character of the data and detailed recording of individual migration histories therefore provides a major advantage over other historical sources of demographic data, such as censuses and family reconstitutions.

Beyond recording demographic events, the database has valuable information on individual occupations, smallpox vaccination status, place of birth, place of last residence, marital status, street address, and relationship to the head of the household (e.g., child, servant, spouse, lodger). Like the demographic information, all of these were also updated upon the annual census registration. The occupational titles have been coded using the historical international standard classification of occupations (HISCO) (van Leeuwen, Maas, & Miles, 2002). This information is used extensively throughout the following papers to identify socioeconomic classes. Classes have been defined using HISCLASS (van Leeuwen & Maas, 2011), a twelve category scheme that is based on the manual or non-manual character of an occupation, level of skill it requires, whether or not it involves the supervision of others, and to which economic sector that occupation belongs. There are a couple of advantages of using HISCLASS to classify the occupations available in the Roteman Database. First, the scheme was specifically developed for occupations in the nineteenth and early twentieth centuries, many of which either do not exist or would be classified in a significantly different way based on modern classification schemes. Second, because the scheme is based on HISCO, which has been developed for eight different countries, it allows for drawing international comparisons between historical populations.

In papers 1 and 2, socioeconomic groups were based on fathers' occupations. In papers 3 and 4, they were based on the occupations of the head of household, which could be either parent or another relative. In the following papers the HISCLASS categories are condensed in various ways both out of necessity and for the sake of interpretability. Some categories simply had too few observations or events of interest to be used in any statistical analysis. Very few individuals during the Roteman era were farmers, for example. For this reason, most of the following papers reduced the original HISCLASS scheme to five categories: Elite (1+2), Lower managers (3+4+5), Skilled workers (6+7+8), Lower skilled workers (9+10), and Unskilled workers (11+12). In addition, all papers include a category for Null/Missing occupations. The final paper uses a more condensed categorization of this scheme to allow for statistical analysis.

To check the quality of the data, sex ratios at birth (secondary sex ratio) were calculated for the entire population and for individual socioeconomic groups. This is meant to discern whether or not there were any serious problems in the reporting of births. If the secondary sex ratio deviates more than a few percentage points from the range of 105-107, there may be problems in the reporting of births for one of the sexes (Coale, 1991). For instance, if neonatal deaths cause births to be systematically underreported, we would expect that the sex ratio at birth would be closer to unity as infant mortality tends to disproportionately affect males. It is clear from table 2 that the secondary sex ratios of the total population and individual classes generally fall within the expected range with only some minor deviations.

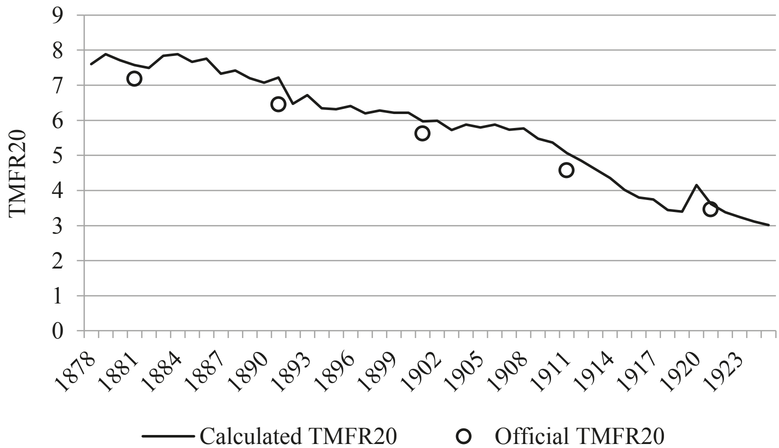
Table 2. Secondary sex ratios for Stockholm by period and socioeconomic class.

	1878-1926	1878-1899	1900-1926
Whole Population	105	103	106
Socioeconomic Status:			
Elite	107	104	107
Lower Managers	107	105	109
Skilled Workers	105	104	105
Lower Skilled Workers	106	103	107
Unskilled Workers	106	106	106

Notes: The secondary sex ratio refers to the number of live male births divided by live female births in a given period.

Source: Roteman Database.

Figure 5. Comparison of the total marital fertility rate from age 20 (TMFR20) calculated from the Roteman Database and from official statistics of Stockholm.



Notes: TMFR20 refers to the hypothetical number of children a married woman would have in her lifetime between the ages of 20 and 49 assuming she survived throughout that period and followed the age-specific fertility behavior of the population.

Source: Roteman Database; For rates derived from official statistics, see Dribe (2009).

In order to verify that the adult female population is accurately reported, I calculated total marital fertility rates from age 20 (TMFR20) and compared them to calculations derived from the official statistics presented in Dribe (2009). As can be seen in figure 5, the calculated rates match the official ones quite closely. The rates calculated from the Roteman data slightly overestimate the TMFR20, but this is likely due to the fact that the districts available in the current dataset do not include some of the wealthiest areas of the city, where fertility was generally lower. Nonetheless, the rates presented here closely follow the trends observed in the official statistics, indicating that the coverage of the Roteman Database was quite good.

Wages and Prices

In paper 3, the demographic data are combined with data on wages and prices for Stockholm to examine mortality responses to short-term economic fluctuations. Paper 3 outlines the calculation of a food price index for Stockholm throughout the coverage period. To briefly summarize, using a local survey administered among working-class households in Stockholm in 1907, *Statistisk Undersökning angående Levnadskostnaderna i Stockholm 1907 – 1908* (Statistical Investigation regarding the Cost of Living in Stockholm 1907 – 1908), and average annual prices reported in Myrdal (1933) and *Statistisk Årsbok för Stockholms Stad* (Statistical Yearbook for Stockholm City), we calculated a 23-item food price index for the period 1877-1926. The index includes only the most heavily consumed items listed in the survey and for which prices were available over the entire period. These restrictions should not influence the accuracy of the budget much, however, as the included items accounted for over 70% of all household expenditures on food, according to the 1907 survey.

Annual wages were collected from several sources. For 1878-1909, unskilled industrial wages for Stockholm County were taken from Lundh et al. (2004). For 1910-1925, data for unskilled workers in Stockholm City come from *Engineering Works* as reported in Bagge, Lundberg, and Svennilson (1933). For 1926 unskilled industrial workers' wages were taken from *Sveriges Verkstadsförenings arkiv* (Association of Swedish Workshop Employers archive). These wages were deflated using the food price index described above. The deflated series was then smoothed using the Hodrick-Prescott filter and the residual values were included in the multivariate event-history models in paper 3 to study short-term mortality responses to wage variation.

Causes of Death

The final major data source employed in this work comes from *Miljö och hälsoskyddsnämnden* (Stockholm Public Health Board), which includes individual-level data on causes of death and has been linked to a portion of the Roteman Database. Already in the mid-eighteenth century parish priests in Sweden were required to record causes of death among their parishioners, but this often led to inconsistencies in the quality and quantity of the information reported. It was only in the 1860s that it became compulsory in cities for all death certificates to be signed by a medical doctor. Because of this, death certificates in Swedish cities in the late nineteenth century are considered to be as reliable as one could expect given the state of medical knowledge (J. Rogers, 1999). Of course, this does not mean the data are perfect. Upon examination it becomes apparent how poorly defined many diseases were. One of the most common causes of death among infants, for instance, was 'congenital weakness' (*'medfödd svaghet'*). Ambiguities notwithstanding, the major killers of the time were fairly easy to identify, even for parish priests with limited medical knowledge.

The data used in paper 4 pertains to all children under 10 years old who were ever present in Stockholm between 1878 and 1926. As of now, only a part of the cause of death register has been digitized. The only selection that was introduced into the digitization process was that it was based on one's district of residence in Stockholm, meaning that not all districts have cause of death information currently available. Among all 36 districts in the Roteman Database, 14 have had at least some cause of death records digitized. Of those, 11 districts have a reported cause for at least 50% of child deaths and three districts this figure is only about 20% of deaths. The analytical models used in paper 4 explicitly take these discrepancies into account by censoring individuals when they are not present in parishes with reported causes of death, controlling for one's parish of residence, and by 'allowing' children to die from unknown causes in the competing risk analyses.

Summary of Papers

Paper 1 – Ready to stop: socioeconomic status and the fertility transition in Stockholm, 1878-1926[1]

The next paper examines how Stockholm's marital fertility transition unfolded for different socioeconomic groups. This is an important description of an urban transition that has largely been lacking from previous literature. Ever since the work of the European Fertility Project (Coale & Watkins, 1986), it has been assumed that certain sub-groups in society were early regulators of fertility. Livi-Bacci (1986) showed that well-before the overall fertility decline aristocracies and religious minorities had begun lowering their fertility. Besides this groundbreaking work, only a few studies have identified social forerunners in the transition (see Dribe & Scalone, 2014; Johansson, 1987; Skirbekk, 2008), but none using individual-level fertility histories for an urban area.

Understanding how different socioeconomic groups experienced the fertility decline can be immensely informative of its underlying causes. This is because many of the proposed explanatory factors of the fertility decline also varied considerably across socioeconomic groups. While this paper cannot explicitly test all of the theoretical explanations for the transition, a description of the decline from a class perspective can at least suggest which are consistent with the patterns we observe. For example, the decline of child mortality has long been touted as an important explanation for why fertility fell in the late nineteenth century (see Notestein, 1953; Reher, 1999). An analysis of the fertility decline for different socioeconomic groups can shed light on the plausibility of this explanation, as it is known that higher status families tended to have lower infant and child mortality in the past (e.g., Bengtsson & Dribe, 2010; Haines, 1995; Haines, 2011; Preston & Haines, 1991), including in Stockholm (Burström, Macassa, Öberg, Bernhardt, & Smedman, 2005), meaning that, if this was an important source of motivation for couples to regulate their fertility, we would expect the decline to have

[1] This chapter was co-authored by Martin Dribe. It has been accepted for publication in the *Economic History Review*.

begun among the upper classes. Others have argued that an early decline among the elite is indicative of unequal access to contraceptive technologies or knowledge which was gradually transmitted to the rest of the population (Casterline, 2001; Cleland, 2001). On the other hand, other explanations have emphasized an important role for changes in the direct and indirect costs of children, which would have motivated couples to regulate their fertility (Becker, 1960; Becker & Lewis, 1973). Historical evidence suggests that most direct and indirect costs of childbearing would have disproportionately influenced the lower classes, implying a rather different pattern of fertility decline. Female labor force participation, for example, was also highly stratified in the past, but would have led to disproportionately higher opportunity costs for the working classes, not the elite. At the start of the Dutch fertility decline, less than 5% of women marrying white-collar professionals had an occupation at the time of marriage, whereas this figure was over 70% for those marrying low-skilled workers (van Poppel et al., 2009). By simply having a good description of socioeconomic differences in levels, timing of decline, and practicing of stopping behavior, we can come closer to understanding which explanations are more or less consistent with the evidence.

The goal of this paper is therefore to analyze the evolution of socioeconomic differences in higher-order (parity 2+) fertility and also in the adoption of fertility control. Both are examined by using individual-level longitudinal fertility histories from the Roteman Database for Stockholm. To study differences in the progression to higher-order births, we employ piecewise constant hazard models to estimate individual parity transitions for married women with one observed birth during the period 1878-1926. This class of proportional hazards models provides a flexible approach to modeling the baseline age-specific fertility risk without making explicit assumptions as to its distribution. The models also account for unobserved heterogeneity among women (e.g., differences in the level and duration of fecundity) by incorporating a mother shared frailty term, which is analogous to controlling for maternal random effects.

We study the differences in the adoption of fertility control by using logistic regression as described in van Bavel (2004b). In this method, the outcome of interest is whether or not a birth interval ends with another birth within five years. The dependent variable takes the value of one if an interval is not followed by another birth and zero if a birth ends the interval. Here, the unit of analysis is the interval, rather than the mother. Because we are interested in the individual, however, and errors will be correlated between intervals from the same mother, standard errors are clustered by mother. In both the event-history and logit models, socioeconomic classes are defined by the husbands' occupations and are time-varying.

The results of our analysis showed that there was a socioeconomic gradient in which the highest groups were the least likely to have higher-order births already from the outset of the transition. Not only was elite fertility at a lower level, but it began its decline at least a decade before that of the working classes, showing that they were forerunners in Stockholm's transition. Near the end of the fertility decline, when the data ends, the elite actually had higher fertility relative to most of the population. The early fertility gap between the groups was not due to differences in the timing of first births or the length of birth intervals, but in the differential adoption of stopping behavior between groups. At the start of the analysis period (1878-1883), the elite were more than twice as likely end fertility at any given interval than the industrial working classes. By 1918-1923, there was no statistical difference in stopping behavior between any socioeconomic groups.

We argue that the socioeconomic differences in the levels, timing, and practicing of stopping behavior are inconsistent with most explanations that emphasize the importance of the changing cost of children. The early decline among the elite could signal a growing preference for higher educated children, but more evidence is needed to support this interpretation. In our view, the socioeconomic patterns described above are consistent with two explanations: an important role of differential child survival and possibly different normative views of contraception. Both of these explanations require qualification, however. By the end of the transition, blue-collar groups continued to have higher mortality, yet most had surpassed the elite by having lower fertility, suggesting a possible weakening of the relationship. Regarding normative differences, members of Stockholm's elite tended to be the leading voices in favor of and against the distribution of contraception, making it unclear as to how receptive higher status groups actually were of new contraceptive ideas and technologies.

Paper 2 – The emergence of the quality-quantity tradeoff during Stockholm's fertility decline

In paper 2 the attention is turned from the causes of the fertility decline to its consequences. Most major theories of the decline assume that having more children will be detrimental to the amount of parental resources to which those children will have access. It is based on this assumption that individual agents will actively attempt to limit their reproduction so as to invest adequately in each surviving child so as to maximize both the satisfaction they can draw from their children and to improve the life chances of their offspring (see Becker & Lewis, 1973; Caldwell, 1976; Easterlin, 1976; Galor, 2011). If this is the case, it should be possible to identify a tradeoff between family size and children's later-life outcomes during the fertility decline. In particular, if the fertility transition was brought about by a large-scale shift in parental investments towards child quality over quantity, one would expect that children born into smaller families at the start of the fertility transition should have had better economic outcomes than those born into larger families.

Most of the research regarding family size and children's outcomes has been concerned with modern populations. It has been shown, for example, that children from larger families receive smaller human capital investments (Cáceres-Delpiano, 2006; Downey, 1995; Hongbin, Junsen, & Yi, 2008; Rosenzweig & Wolpin, 1980), have worse educational outcomes (Ponczek & Souza, 2012), and receive diminished financial transfers from their parents (Emery, 2013). Agreement as to the strength and direction of some of these relationships is not unanimous, however (see Angrist, Lavy, & Schlosser, 2010; Ferrari & Dalla Zuanna, 2010; Fitzsimons & Malde, 2014). For historical populations, especially during the fertility transition, this relationship has hardly been examined. There is some evidence from Belgium, the Netherlands, rural Sweden and England that suggests that individuals born into larger families had worse outcomes in terms of status attainment and health, and that this relationship may have strengthened during the fertility decline (Bras, Kok, & Mandemakers, 2010; Hatton & Martin, 2010; van Bavel, 2006; van Bavel, Moreels, van de Putte, & Matthijs, 2011; Öberg, 2015). The goal of this paper is therefore to contribute to the historical literature on the relationship between family size and outcomes by examining the association between sibling exposure and intergenerational social mobility for cohorts of boys born in Stockholm between 1878 and 1896.

These cohorts were born at different phases of Stockholm's fertility transition and were exposed to different educational regimes during childhood. For those born before the fertility decline (1878-1883), education was fairly high (around 90% of the school-age population was enrolled), but it was also unstable in the short term. The later-born cohorts, on the other hand, had enrollment rates approaching 100% and short-term variation in the trend largely dissipated. This is an important difference, as it has been argued that when the demand for human capital is greater, parents will invest more heavily in child quality versus quantity, which will eventually lead to worse outcomes for children from larger families (Galor, 2011). If an association between sibling exposure and intergenerational social mobility can be identified, it is therefore expected to be strongest among the latest born cohort, as the growing demand for human capital will have placed a higher premium on education for those children and thus lead to a greater differentiation in labor market outcomes later in life based on family size. Furthermore, if education is driving this relationship, one should expect that children originating from higher socioeconomic classes should be less impacted by sibling exposure, as their parents should have the material and social means to avoid some of the negative effects.

This paper also contributes to the existing literature by conceptualizing sibship size as a continuous measure of shared person-years. In contrast, most studies define sibship size as the number of surviving siblings an individual had at a given age. But this definition is problematic, especially in populations with high mortality, changing birth intervals, or young ages at leaving home. For example, let us consider two individuals who had one surviving sibling at age 15. One of those individuals may have been born a twin, while the other may have had a sibling born when they were nine years old. Using the traditional measure of sibship size would equate these two individuals' exposure to their siblings, when in reality they had vastly different experiences growing up. Because the data used in this study are longitudinal, it is possible to calculate not just the number of siblings to whom an individual was exposed, but also the duration and intensity of their exposure. Using this measure to complement the discrete surviving siblings definition, I have defined sibling exposure as the cumulative shared person-years an individual experienced until age 15.

It was necessary to restrict the sample from the Roteman Database in order to examine the relationship of interest. First, individuals were required to have been born in Stockholm so that complete sibling exposure could be calculated. Second, only male children were included in the analysis due to practical difficulties in dealing with female occupations during the period in question. Third, individuals must have been present in Stockholm until at least 30 years old. Fourth, children must come from a home with a father present so that it will be possible to compare the socioeconomic classes of both the father and son and, therefore, generate a mobility variable. Fifth, both the father and son must have had non-missing occupational information. These restrictions allowed for the following of over 7,200 males from 18 birth cohorts.

With above sample, multinomial logistic regressions were estimated in which the dependent variable could take on three values (1=upward mobility; 2=non-mobility; 3=downward mobility). The main independent variables of interest were the aforementioned sibling exposure variables. The results showed that there was a statistically significant negative relationship between upward mobility and sibling exposure regardless of how it was defined. No association was found with downward mobility. Extending the model to include an interaction between sibling exposure and birth cohort, predicted probabilities were generated at different levels of exposure. The model showed that there was no statistically significant relationship between sibling exposure and upward mobility until the fertility transition had already started. The mobility penalty was only visible for the cohort born between 1891 and 1896, and it was only for individuals with more than two surviving siblings. Furthermore, the strength of this relationship was inversely related to one's origin status, suggesting that parents from higher socioeconomic groups could buffer some of the negative effects of sibship size.

The results presented in this paper show that the negative relationship between sibling exposure and intergenerational mobility only emerged shortly after the fertility decline began. I argue that this was due to a rising demand for human capital, to which parents with fewer children could more easily respond. That the observed relationship operated through human capital attainment is evidenced by the fact that children originating in higher socioeconomic strata were buffered against the negative effects of sibling exposure by their parents' greater of income, higher levels of human capital, and expansive social networks. Furthermore, larger families only made it less likely for children to reach occupations that required higher education, but had no influence on one's probability of attaining statuses requiring no education.

These details are suggestive of an explanatory role of the quality-quantity tradeoff in the fertility decline, but with important caveats. First, the emergence of the tradeoff seemingly occurred simultaneously across socioeconomic groups, which is inconsistent with the class-specific patterns of fertility decline observed in Stockholm. Second, the strength of the tradeoff was the weakest for the highest status groups, who were the first to limit their fertility. Third, it is unclear how important the quality-quantity tradeoff was regarding fertility limitation compared to other factors, such as improvements in child survival. It may be that the relative importance of the tradeoff in determining individual fertility grew as reproductive behavior became decoupled from mortality. This would explain, for example, why the fertility of the lower classes continued to fall below that of the elite despite persistent differences in infant and child mortality.

Paper 3 – Industrialization and inequality revisited: mortality differentials and vulnerability to economic stress in Stockholm, 1878-1926[2]

The changes and distribution of living standards during industrialization are of primary interest to economic historians, but their development in cities during the late nineteenth and early twentieth centuries remains a contentious topic. This is partially because there is a lack of agreement about just how living standards should be defined, leading to a variety of proxies based on economic, anthropometric, and demographic data and therefore various interpretations of the urban quality of life during the era (Crafts, 1997; Feinstein, 1998). This paper uses infant and child mortality to evaluate inequality in urban living standards in two ways. First, we analyze socioeconomic differentials in infant and child mortality over much of Stockholm's mortality decline and industrial growth. Then, we estimate

[2] This chapter was co-authored with Martin Dribe. It has been accepted for publication in the *European Review of Economic History*.

mortality responses to short-term fluctuations in a newly constructed food-adjusted wage series to identify short-term economic vulnerability in the population.

Mortality at young ages is a valuable indicator of living standards, as it reflects important factors such as parental income, work intensity, residential conditions, access to medical care, exposure to injury and average nutrition (Mosley and Chen 1984). Furthermore, unlike other proxies for living standards, mortality data can often be found for entire populations, or at least large parts of them, while individual-level economic and anthropometric indicators are normally only available for specific occupations and sub-groups. By studying relative mortality differentials and class-specific responses to short-term economic stress, we can therefore obtain a fairly comprehensive view of living standards inequality during industrialization.

In order to identify short-term economic fluctuations, we used a cost of living survey of 250 families living in Stockholm in 1907-1908 to construct a food price index. These surveys provided information on the quantities of different food items purchased by households and these were used as the weights in the index. The prices of the 23 items included in the basket were obtained from Myrdal (1933) for the period 1877-1905 and from official reports by the city government for the period 1906-1926. The price index was then used to deflate a nominal wage series for unskilled industrial workers for the entire period (see section 1.5.2 for details), which was then de-trended using the Hodrick-Prescott filter. The residual values from the HP filter were later included in our multivariate event-history analysis.

To estimate socioeconomic differentials in infant and child mortality, piecewise constant hazard models were employed for the entire infant (age 0-1) and child (age1-9) populations ever present in Stockholm between 1878 and 1926. The results showed relative class differences in infant and child mortality were strong and persistent throughout industrialization, despite the fact that both were declining in absolute terms. This finding is interesting because it suggests that even though average living standards improved, the upper classes continued to retain an advantage in one of the most basic living standards indicators of all, survival. The models were then extended to include the residuals of the food-adjusted wage series, which allowed for evaluating the short-term vulnerability of different socioeconomic groups during the period. The results surprisingly show that all socioeconomic groups continued to be vulnerable to short-term economic variation into the twentieth century. That there were no class differences in the mortality response between classes is puzzling, as it is unrealistic to expect that wealthy families were so constrained that a one percent change in wages would influence their children's risks of mortality. Instead, evidence is offered suggesting that the similarity in the short-term response was due to the fact that highly infectious diseases proliferated during times of low wages, which may have originated in the working classes.

We argue that the persistence of class differentials in infant and child mortality was a result of growing socioeconomic segregation in the city during the period and possibly nutritional differences between classes. Although there seems to have been little change in living standards inequality throughout the period, this does not mean that living standards remained low. The working classes saw much more dramatic improvements in infant and child survival throughout the period and were earning three times more in 1926 than in 1878 in real terms.

Paper 4 - Disparities in death: the changing socioeconomic distribution of cause-specific child mortality in Stockholm, 1878-1926

The final paper of the dissertation looks more closely at the persistence of socioeconomic differences in child mortality (age 0-9) by considering the distribution of specific causes of death. While all socioeconomic groups experienced mortality decline more or less simultaneously, there is evidence that relative differences in mortality may have remained virtually unchanged throughout the process (Antonovsky & Bernstein, 1977; Haines, 2011; see also paper 3). This is especially surprising because many of the period's greatest threats to child survival were confronted by the sweeping public health initiatives of the era, many of which effectively decoupled individual wealth from access to hygienic conditions. By analyzing the development of inequality in cause-specific mortality throughout the mortality decline we can obtain a better understanding of why class differences in mortality failed to converge and also get a multi-dimensional view of the development of living standards during industrialization.

Link and Phelan (1995) provide a framework to explain why, despite a changing epidemiological environment, socioeconomic differences in health persist in the long run. They argue that socioeconomic status is a 'fundamental social cause' of disease. A fundamental social cause is one which has four main features. First, it influences multiple disease outcomes. Second, those outcomes are affected by more than one risk factor. Third, it involves one's access to economic and social resources, such as income, knowledge, political clout, and social networks, which can be used to avoid illness as well as to minimize the negative effects of disease. Fourth, the relationship between fundamental causes and health is reproduced over time as new dominant diseases emerge and as knowledge and treatments of disease are developed. Thus, according to their framework, even as some diseases become less dependent on individual resources through, for example, public health interventions, other diseases will become relatively more dependent on them, allowing socioeconomic inequality in health to persist. The aim of this paper is therefore to study socioeconomic differences in cause-specific mortality during the mortality decline. Of particular interest is whether or not all causes of death continued to be unequally distributed throughout the population or if there was a shift in the relative importance of some causes over others.

This paper analyzes individual-level cause of death information from the Stockholm Public Health Board that has been linked to the Roteman Database. Causes of death have been classified using the scheme proposed by Bengtsson and Lindström (2000) into five categories: (1) airborne diseases, (2) food and waterborne diseases, (3) noninfectious diseases and accidents, (4) congenital malformations and birth defects, and (5) unknown causes. These categories were then used as outcomes in five separate Cox proportional hazards models in a competing risks framework to estimate the cause-specific hazards of dying for three socioeconomic groups: white collar workers, skilled blue collar workers, and low and unskilled blue collar workers. An additional category was included to capture missing occupations. This categorization differs slightly from the previous papers as it was necessary to combine groups in order to have a sufficient number of competing events for analysis in each class and time period.

The results showed that, during the mortality decline, socioeconomic differences in almost all causes of death converged so that, by 1926, there were no statistical differences between classes. The only group of causes that did not follow this pattern was that containing airborne diseases, the largest specified category. For airborne disease mortality, slow convergence between the white collar and skilled workers group occurred throughout the period. This convergence did not occur between the low and unskilled workers and white collar workers however. In fact, the relative differences between the groups became even larger. I argue that the development of the municipal water system was successful at eliminating the socioeconomic gradient in waterborne mortality by disassociating access to clean water with individual resources. This may also have helped to reduce differences in non-infectious disease mortality. As resources became less important in securing a health advantage with respect to some diseases, they became relatively more important for others. I provide evidence that the persistence of airborne mortality differentials was driven by growing inequality in exposure to two of the proximate determinants of mortality, nutritional deficiency and residential crowding, both of which remained heavily dependent on individual resources.

The findings of this paper illustrate a nuanced view of the development of living standards inequality during industrialization. They show that many of the improvements in urban living standards that occurred during this time, like the expansion of sanitation infrastructure, truly may have benefited the population as a whole and led to equitable child health outcomes. Differences in mortality from food and waterborne illness and noninfectious diseases and accidents completely disappeared by the end of observation. At the same time, the findings show how, in an unequal society, individual resources can continuously be leveraged to reproduce inequality in the most basic living standards indicators of all, health and survival, over generations, even in a context of falling mortality and a changing epidemiological environment.

Discussion and Conclusion

The goal of this dissertation was to shed light on two of the big questions that have occupied economic historians for decades: why did fertility decline in the late nineteenth century? And how did industrialization affect the distribution of living standards? Despite a tremendous amount of work on both topics, there remain serious gaps in our knowledge of these processes. One such gap is a lack of individual-level evidence as to how the fertility transition unfolded and how living standards inequality developed within large urban areas. The present work has been able to contribute new evidence to these debates by studying socioeconomic heterogeneity in demography during Stockholm's industrialization.

The first half of the dissertation brings new evidence to the debate regarding the fertility transition's causes by studying socioeconomic differences in fertility as well as how family size influenced children's later-life outcomes. I showed that Stockholm's socioeconomic elite were the earliest practitioners of fertility limitation in the form of stopping behavior, were the first to exhibit declining birth rates, and their children's later-life mobility prospects were the least sensitive to the size of the family in which they were raised. For rest of the population, the onset of the decline and the time it took for a group to match the same level of fertility limitation as the elite varied inversely with socioeconomic class. Furthermore, it was the children of the lowest socioeconomic groups whose chances for upward mobility were the most vulnerable to sibling exposure. Together, the findings of these two papers provide important clues regarding the validity of some of the most common explanations for the fertility transition.

Hypotheses that emphasize the importance of changes in the direct or indirect costs of children are simply inconsistent with the patterns observed in Stockholm. Many of the factors that would have made children more costly for parents, such as a growing demand for education and increasing female labor force participation, exerted much greater pressure on the lower end of the socioeconomic distribution than on the top. In Stockholm, the direct costs of primary schooling for all children were very low and any indirect costs, such as losing children as a source of income, would have almost exclusively impacted the poorer segments of the working class. I have identified that there was likely a tradeoff between family size and investments in higher education that arose at the start of the fertility transition, but this relationship emerged for all socioeconomic groups simultaneously and was the strongest among the lower classes. Likewise, if it was increasing opportunity costs of childbearing that motivated the fertility transition, one would have also expected the lower classes to have been leaders in the decline. In Stockholm, female labor force participation was practically non-existent among married women in elite groups, while those married to blue-collar workers were much more likely to have a formal occupation.

The socioeconomic patterns described in this dissertation instead were much more consistent with explanations emphasizing the importance of improvements in child survival. The class gradient in fertility was matched by an even stronger gradient in infant and child mortality. In the early years of the fertility transition, almost one-third of all births to the women in the unskilled group occurred within two years of the death of a previous child. For the elite, this figure was about half the size. What share of the overall differences in total fertility were due to differences in child mortality cannot be said with certainty, but the enormous disparities in child 'replacement' suggest that mortality played an important part. This interpretation requires some qualification, however. First, because of the timespan of the database, we are unable to observe the exact start of the fertility transition among the elite, meaning that we are also unable to identify if their children's mortality had begun to decline earlier or if they ever had similar levels of fertility to other socioeconomic groups. A second qualification is that, even if declining child mortality was an important incentive for parents to lower their fertility, the relationship between the two clearly became much weaker as the transition neared its end. Infant and child mortality continued to be disproportionately higher in the working classes, yet most groups achieved lower fertility than the elite by 1926. It is possible that the continued decline among these groups, in spite of their higher child mortality, was driven by a strengthening of the tradeoff between quality and quantity, which I have shown was more severe among the working classes.

The findings here are also consistent with a diffusion of new ideas or technologies that may have promoted fertility limitation. In terms of the temporal patterns we observed, Stockholm's fertility decline certainly looks like a stereotypical top-down diffusion process. The elite were the first to practice early stopping behavior followed by the middle class, and the lower classes were the last to catch up. Unfortunately, this interpretation is difficult to move beyond conjecture, because it is unclear exactly what diffused. A large body of evidence suggests that fertility limitation as a behavior was not an innovation *per se*, but was known, if not consistently practiced, for centuries, including in Sweden (see Amialchuk & Dimitrova, 2012; Bengtsson & Dribe, 2006; Brown & Guinnane, 2002; Dribe & Scalone, 2010; McLaren, 1992; Santow, 1995; van Bavel, 2004a). At the same time, the excessive vigilance of the Swedish government during the fertility transition does suggest that modern contraceptives may have become more widely available. On the other hand, if it was a diffusion of new ideas regarding, for example, family size or gender relations within marriage, rather than of new behaviors or technologies, it may be virtually impossible to prove empirically.

The core findings of this work thus contribute to a growing body of research from rural areas showing that the socioeconomic elite were indeed forerunners in the overall decline (Bengtsson & Dribe, 2014; Bras, 2014; Breschi, Esposito, Mazzoni, & Pozzi, 2014; Dribe & Scalone, 2014; Vézina, Gauvreau, & Gagnon, 2014). More rigorous empirical work is still needed, however, to determine exactly why these forerunner groups were early practitioners of fertility control.

The latter half of the dissertation has contributed to our understanding of living standards inequality during industrialization by studying socioeconomic differentials in infant and child mortality and mortality responses to short-term economic variation. Relative mortality differentials, particularly between the upper and lower classes, remained largely unchanged throughout Stockholm's main period of industrial growth. This was in spite of large declines in levels of mortality and absolute differentials between groups. The analysis of cause-specific mortality revealed that this persistence was not simply the preservation of the status quo, but that the determinants of those differences shifted dramatically. In the early years of observation, children of the lower classes were more likely to die from virtually any cause of death. As time wore on, however, mortality risks for many causes actually equalized across socioeconomic groups. Ultimately, it was only one category of diseases that continued to disproportionately impact the lower socioeconomic strata, but it was to such an extent that overall relative differentials remained virtually constant. Interestingly, the results regarding mortality responses to short-term economic fluctuations revealed that the persistence of inequality may have also negatively impacted those who were relatively better-off. Because of the poor living conditions of the working classes, short-term decreases in individual purchasing power tended to increase their risk of child mortality, likely due to the deterioration of an already fragile nutritional status. Periods which saw economic downturns were consistently associated with increased prevalence of both endemic and epidemic infectious disease mortality, which ultimately led to similar short-term variation in child mortality across all socioeconomic groups.

These results offer some evidence suggesting that the economic, social, and political changes accompanying industrialization may have truly benefited the masses. In some basic ways, the living standards of the lower classes began to approach those enjoyed by the elite. This is evidenced by the disappearance of differences in mortality from food and waterborne diseases as well as from non-infectious diseases. I have not explicitly tested why these differentials disappeared, but it likely was related to the further expansion of the water network and the vigilance of municipal authorities in inspecting foodstuffs. If this was the case, it would highlight the enormous impact that investments in public goods may have had on living standards during this period.

Yet the convergence of some forms of mortality should not be overstated. Widespread access to clean water and food may have been some of the greatest public health achievements in history, but even these were not enough to dislodge the elite from their privileged position with regard to child mortality. Despite the decoupling of individual resources from significant health risks of the era, families in the top socioeconomic strata continued to find ways to utilize their superior resources to maintain a higher standard of living for their children. Although some conditions had improved to the point in which there were no differences in outcomes between the upper and lower classes, this would have been little consolation for working-class parents who continued to lose almost twice as many children as those in elite groups.

This dissertation has shown how studying historical phenomena from an individual perspective can provide new insights into old problems. By studying socioeconomic heterogeneity in demography, we have seen that the early fertility decline among elite groups cannot be consistent with many common explanations of the transition. And the persistence of inequality in urban mortality indicated that industrialization did little to bring the living standards of the working classes closer to those of the elite in relative terms. The work presented here does not close the book on either of these issues, but rather highlights the importance of having more individual-level research to resolve why fertility declines and how economic growth influences the distribution of living standards.

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Paper 1

Ready to Stop: Socioeconomic status and the fertility transition in Stockholm, 1878-1926[1]

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Abstract
The Western fertility decline is arguably the most significant demographic change to have occurred in the past 200 years yet its causes and processes are still shrouded in ambiguity due to a lack of individual-level longitudinal data. A growing body of research has helped improve our understanding of the decline's causes by examining the development of socioeconomic differences in fertility using historical micro-data, but these have largely only considered rural areas where fertility was generally slower to decline. This paper contributes to the literature by utilizing individual-level data from Stockholm, Sweden between 1878 and 1926 to examine socioeconomic differences in fertility and the adoption of stopping behavior during the city's transition. We find that a clear class pattern emerged in which the elite were early practitioners of fertility control followed by the working classes. As the transition unfolded, socioeconomic differences in overall fertility differentials and stopping behavior were minimized. The implications of these findings for major explanations of the decline are discussed in the concluding section.

JEL classifications: J13, N33, N93
Key words: Fertility transition, socioeconomic status, urban, diffusion

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The historical fertility transition in Western Europe and its offshoots is considered by economists and economic historians to be one of the most significant factors leading to sustained economic growth within these societies.[2] It marked the break with Malthusian stagnation and led to improvements in standards of living via technological advancement and ubiquitous increases in real wages. Despite its importance, fundamental aspects of how it proceeded are still ambiguous. In this paper, we shed light on some of the crucial details of fertility change that have often been proposed but, until now, have rarely been corroborated. Using individual-level, longitudinal data from Stockholm, Sweden during its fertility decline, this paper looks at how fertility and the adoption of fertility control evolved throughout the transition for distinct socioeconomic groups. Our aim is to provide a detailed account of socioeconomic differentials in the adoption of new behavior in an urban area during industrialization, a crucial piece of information necessary for understanding the microeconomic foundations of the transition. While this is not a causal analysis, it is a necessary description that can inform theoretical models of the fertility transition and its role in modern economic growth.

Despite the depth of theoretical research concerning the fertility decline, there is a surprising paucity of empirical work using detailed demographic data and directly measuring fertility. This is in no small part due to data limitations. The most famous body of work sprang from the European Fertility Project, which focused on fertility decline at the subnational level at various degrees of aggregation.[3] Among its findings were that (1) urban areas had lower fertility than rural areas before the fertility transition, (2) urban areas tended to begin their fertility declines prior to rural areas, (3) they progressed more quickly through the decline in its initial stages, and (4) elite social groups decreased their fertility before the onset of the larger decline.[4] While the existence of urban-rural differentials has been well-documented,[5] the socioeconomic patterns of fertility decline have received less attention.

[2] Galor, 'Demographic transition and economic growth', p. 495; Galor, *Unified growth,* p. 46; Guinnane, 'Historical fertility', p. 589.
[3] Coale and Watkins, *Decline of fertility in Europe*.
[4] Livi-Bacci, 'Social-group forerunners'; Sharlin, 'Urban-rural differences in Europe'.
[5] For example,Dribe, 'Demand and supply factors'; Haines, 'England and Wales revisited'; Knodel, *Decline of fertility in Germany*; Mosk, 'Rural-urban fertility'; Sharlin, 'Urban-rural differences in Europe'.

Some evidence of socioeconomic elites acting as forerunners has been presented for France, Belgium, Germany, and Sicily, but few of the studies have utilized individual-level data or had the possibility of following individuals over time and in an urban context.[6] While these findings have offered valuable insight into the fertility transition, the statistical methods, nature of the data, and levels of aggregation used have masked many of its dynamics.[7] This highlights the importance of exploring longitudinal micro-data for a better understanding of the decline's microeconomic implications.[8] If any meaningful theoretical explanations of demographic and economic change can be developed, it is necessary to understand what actually happened among individuals in cities during the fertility decline.

Our study fills this gap by utilizing the Roteman Database, an individual-level longitudinal register for Stockholm, Sweden between 1878 and 1926. In addition to recording demographic events, the data include occupational information which we utilize to identify socioeconomic status. This allowed for the use of event-history techniques and logistic regression to analyse how socioeconomic status was associated with fertility behavior and the adoption of fertility control and how these relationships changed throughout the fertility transition. Our main findings indicate that high-status individuals had the lowest fertility already at the start of the transition, were the first to show a significant decline in birth risks, and were the earliest practitioners of stopping behavior. However, as the transition unfolded, the middle and lower classes experienced a much more rapid fertility decline and most eventually had lower fertility than the elite. Near the end of the transition, the elite had higher period fertility than all groups but the unskilled, which contradicts simple accounts of a reversal of differentials by social status during the demographic transition.[9] Furthermore, there are clear indications that the degree of fertility control had largely converged between

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[6] Cummins, 'Marital fertility and wealth', uses family reconstitution methods for rural France and only utilizes 423 observations; Gutmann and Watkins, 'Differences in fertility control' looks at rural La Hulpe in Belgium using longitudinal data, but only covered the pre-transitional period ; Knodel, *Decline of fertility in Germany*; Schneider and Schneider, 'Going forward'; Dribe and Scalone, 'Social class and net fertility'; Bengtsson and Dribe, 'Fertility transition in Southern Sweden'.
[7] See Brown and Guinnane, 'Regions and time in fertility transition', for a critique of the Princeton Fertility Project's methodology.
[8] Guinnane, 'Historical fertility', p. 610.
[9] Skirbekk, 'Fertility by social status', pp.149-150.

socioeconomic groups. The implications of these findings for future research are discussed in the concluding section.

I

Traditionally, the debate regarding the causes of the fertility transition has revolved around the relative importance of two types of explanations: adjustment hypotheses and innovation-diffusion hypotheses.[10] Adjustment hypotheses argue that fertility declined as incentives for smaller families became stronger due to changes in child mortality, the value of women's time, the cost of education, or the rise of urban society, to name a few. Innovation-diffusion hypotheses, on the other hand, have emphasized the importance of the emergence and spread of new ideas and technologies related to contraception. In recent years, historical demographic research using micro-data has found support for both of these views by studying socioeconomic fertility differentials during rural transitions,[11] yet little is known about how class differences in fertility developed in urban areas. In the Swedish context, this is an important detail missing from the literature, as it has been shown that urban areas were the leaders of the fertility decline.[12] Although fertility differentials *per se* cannot definitively prove which explanations, if any, are correct, understanding how they evolved during the transition can direct our attention towards specific causal factors.

Our analysis can contribute to this debate specifically by identifying whether or not there were socioeconomic differences in levels of fertility, the onset of the decline, and the practicing of stopping behavior at the start of the transition. A view that has been gaining empirical support from recent individual-level studies of rural areas has been that high-status groups served

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[10] Carlsson, 'Innovation or adjustment', p. 149. Some notable attempts to integrate these types of hypotheses have been made by Easterlin, 'Economic framework for fertility analysis', Easterlin and Crimmins, *The fertility revolution,* and Rosero-Bixby and Casterline, 'Modelling diffusion effects'.

[11] Dribe and Scalone, 'Social class and net fertility'; Vézina, Gauvreau, and Gagnon, 'Fertility differentials in Quebec'; Maloney, Hanson, and Smith, 'Frontier fertility'; Breschi et al., 'Fertility and stratification in Sardinia'; Bras, 'Structural and diffusion effects'.

[12] Dribe, 'Demand and supply factors', p. 76.

as leaders in the overall decline and were eventually followed by the rest of the population.[13] There may be several reasons for this pattern. On the one hand, it is possible that some changing structural conditions would have motivated the elite to limit their fertility before other groups. For example, infant and child mortality tended to be substantially lower and to fall faster among elite groups in historical populations, implying that they would have required fewer births to reach a desired family size. In Stockholm, infant mortality rates of unskilled workers were about 70 per cent higher than those of white collar professionals in the late nineteenth century,[14] and such a social gradient has been observed repeatedly in populations in the US and Europe.[15] Others have argued that an early decline among the elite may have been a response to the threat of downward social mobility for themselves or their children.[16] On the other hand, it is also possible that the forerunner status of the elite may have been a result of greater opportunities to practice contraception in those circles. Qualitative evidence from England has shown that working-class women during the decline were often uncertain of modern contraceptive methods, while at the same time cognizant of the fact that upper-class women had access to and knowledge of them.[17] Empirical work on the Dutch fertility transition has found that the wives of doctors, who certainly would have had greater knowledge of contraception than any other profession, had substantially lower fertility, showed more pronounced decreases over time, and also tended to end their childbearing at younger ages than other married women, including those married to men with other high-status occupations.[18]

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[13] Dribe and Scalone, 'Social class and net fertility'; Vézina, Gauvreau, and Gagnon, 'Fertility differentials in Quebec'; Breschi et al., 'Fertility and stratification in Sardinia'; Bras, 'Structural and diffusion effects'; Bengtsson and Dribe, 'Fertility transition in Southern Sweden'.
[14] Burström et al., 'Water and sanitation'; Burström and Bernhardt, 'Social differentials in mortality'.
[15] Preston and Haines, *Fatal years*; Haines, 'Inequality in US mortality'; Bengtsson and Dribe, 'Quantifying family frailty'; Antonovsky and Bernstein, 'Social class and infant mortality'; Haines, 'Differentials in infant and child mortality'.
[16] Johansson, 'Status anxiety'; Dumont, *Dépopulation*; Westoff, 'Social mobility hypothesis'.
[17] Seccombe, 'Starting to stop', pp. 159-70.
[18] van Poppel and Röling, 'Physicians and Fertility Control in the Netherlands', pp. 179-80.

But there is little evidence suggesting that this socioeconomic pattern of decline also occurred in urban areas.[19] In fact, there are good reasons to expect an entirely different pattern in which the lower classes would have been the first to limit their fertility. Mainstream microeconomic theories generally emphasize that the decline was a response to the changing indirect and direct costs of children due to, for example, increasing female labor force participation or the expansion of education.[20] The historical distribution of these changes would lead us to expect disproportionate motivation to regulate fertility to first emerge among the lower classes, not the elite. The limited data available on female labor force participation, for instance, suggests that this too was highly stratified in the past. In the Netherlands during the nineteenth century, women marrying into the upper classes were much less likely to have an occupation than those marrying manual workers. In 1870-9, the beginning of the Dutch fertility transition, less than 5 per cent of women marrying white-collar professionals had an occupation at the time of marriage, while this figure was over 70 per cent for those married to low-skilled workers.[21] Data from England and Wales prior to the decline also support this view. There, women tended to contribute a greater share of household income when their husbands worked in lower skilled occupations.[22] Our own calculations for Stockholm between 1878 and 1926 also show that female labor force participation among married women increased for most socioeconomic groups, but mainly among the lower classes. In 1920, about one-third of women married to unskilled workers were employed, while only about 2 per cent of those married to high-skilled, white-collar workers had an occupation. Together, these facts support the idea that the opportunity costs of women among the lower classes should have been higher and motivated them to regulate their fertility.

The expansion of education also would seemingly exert disproportionate pressure on working-class couples to limit their fertility. A recent study of the effects of compulsory primary schooling in the United States showed that

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[19] Alter, *Family and the Female Life Course*, p. 189, finds some evidence of an early decline among the elite and that fertility limitation later emerged more or less simultaneously in all other occupational groups.
[20] See Becker and Lewis, 'Quality-quantity interaction'; Becker, 'Economic analysis of fertility'.
[21] van Poppel, van Dalen, and Walhout, 'Emergence of the housewife', p. 109.
[22] Horrell and Humphries, 'Women's labour force participation', pp. 102-3.

it was particularly children of the lower classes whose attendance increased due to the legislative changes, while the children of the upper classes had already been much more likely to attend school prior to the reforms.[23] The nature of schooling in Stockholm would similarly suggest that only the poorest families should have felt compelled to reduce their fertility as a response to educational expansion. There, the costs of primary schooling were low in the late nineteenth century. Most children only attended school for about six years, usually starting at the age of six or seven. Schooling was subsidized by the state and parents were only responsible for providing basic supplies and clothing for their children. These basic costs appear not to have been a deterrent for the large majority of parents, as 95 per cent of school-age children were registered as being enrolled in daily lessons by the turn of the century.[24] Parents who were unable to afford the cost of supplies could find support from the Poor Relief Board, but in order to be eligible for these funds parents must have been physically or mentally incapable of providing for their children.[25] If any parents were pushed to lower their fertility based purely on the rising cost of children via compulsory education, it would have been those near poverty. Evidence from a local cost of living survey in 1907 supports this assertion as investments in children's education varied little across income groups, amounting to only about 1 per cent of a household's total expenditures.[26]

The above discussion shows that there was likely sufficient pressure to motivate fertility limitation throughout the socioeconomic strata, but that such motivation would have likely originated from very different sources. Furthermore, there may have even been discrepancies regarding contraception in the knowledge, methods, and attitudes available for different socioeconomic groups. This highlights the importance of identifying whether or not there were socioeconomic differences in the timing of the decline, in levels of fertility, and the implementation of stopping behavior, as these details could be suggestive of some of the underlying causes of Stockholm's fertility transition.

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[23] Rauscher, 'Educational expansion in the United States', pp. 1409-16.
[24] Stockholms Stads Statistiska Kontor, *Statistisk årsbok för Stockholms stad 1905*, p. 56.
[25] Holmlund, 'Poor laws and schooling in Stockholm', p. 46.
[26] Stockholms Stads Statistiska Kontor, *Lefnadskostnaderna i Stockholm,* p.100.

II

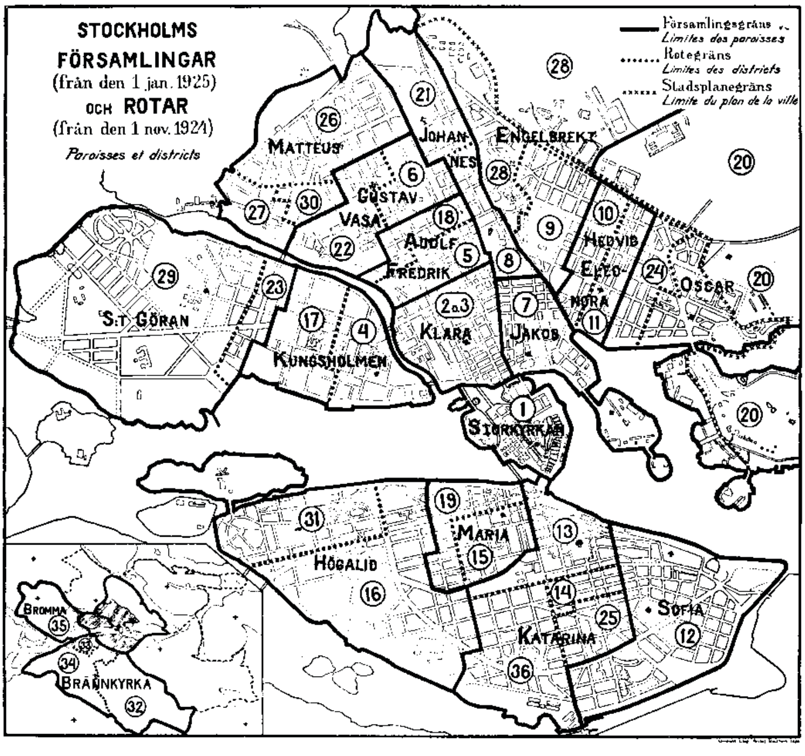
The data for this study come from the Roteman Database, which contains all individuals who lived in Stockholm in the period 1878-1926. While a few of the less-populated parts of the city have still not been digitized, the data covers over 70 per cent of the original source material. The Roteman's Institution was established in 1878 as a response to the growing burden of data collection placed on parish priests in Stockholm. On 1 January 1878, the city was divided into 16 districts, which often simply took on the parochial borders already existing within the city. Each of these districts was assigned an administrator, who was responsible for registering individuals in the system and all births, deaths, and migration.[27] In 1926, the system was officially abandoned for the same reason it was created: rapid population growth. The number of districts within the city had increased from 16 in 1878 to 36 in 1926 due to numerous subdivisions of existing districts and also the amalgamation of two adjacent rural areas. The layout of the city's districts may be seen in figure 1.

A subset of the database was extracted for this study, which consists of all women ever living in Stockholm between the ages 15 and 49 during the period and all individuals with a connection to those women, including family members, household employees, and lodgers. The structure of the data is spell-based with information explaining how each spell began and ended. For example, it is known if a spell began with a birth and ended with migration out of the city or to another district within the city. The dataset contains information about occupations, birthdates, the position of individuals within a household (e.g. head, servant, lodger), one's place of birth, marital status, and sex. Information on marriage dates is only partially available, though married couples can be identified by their relation to the head of household. Although the data structure is longitudinal, there were often only partial dates available, usually consisting only of a year or of a year and month. To be able to take advantage of the longitudinal quality of the data, we therefore needed to account for inconsistencies in how dates were reported. For these cases, dates were replaced providing median exposure to individuals based on the information they had available. That is,

[27] Geschwind and Fogelvik, 'Stockholm historical database'.

missing entry dates would be defined as 1 July and missing exit dates as 30 June if both the month and day were missing. If only the day was missing, the median day of that month was imputed. This seems to be the most reasonable way of dealing with exposure when no other information can be used to identify what those missing dates should have been. Of all women in our analysis sample, 54% had at least one date in which the month was unknown, though the majority of those only had one or two incomplete dates. As a sensitivity check to ensure that this imputation did not influence our results, we re-estimated our models using only individuals with complete registry of dates. The results remained robust to this restriction.

Figure 1. Data collection districts of Stockholm on 1 November 1924.



Source: *Statistisk årsbok för Stockholms stad* [Annual Statistical Abstract for Stockholm City] (1924), Stockholm City Archives. Online at: http://www.stockholmskallan.se/Soksida/Post/?nid=18363

Despite the impressive detail of the dataset, it has never been used to examine the fertility transition. Because of the availability of occupational information, the data allow for an examination of fertility differentials by socioeconomic class in an urban setting, which can in itself provide important clues to understanding why fertility declined. Occupations were pre-coded using the Historical International Standard Classification of Occupations (HISCO).[28] Using the HISCO information, a social class variable was created using HISCLASS, which generates a 12-category classification scheme based on required skill level, degree of supervision, manual or non-manual character of work, and whether it is an urban or rural position.[29] The classes included are: 1) Higher managers, 2) Higher professionals, 3) Lower managers, 4) Lower professionals, clerical and sales personnel, 5) Lower clerical and sales personnel, 6) Foremen, 7) Medium skilled workers, 8) Farmers and fishermen, 9) Lower skilled workers, 10) Lower skilled farm workers, 11) Unskilled workers, 12) Unskilled farm workers. These 12 classes were grouped into five categories: elite (1+2), lower managers (3+4+5), skilled workers (6+7+8), lower skilled workers (9+10), and unskilled workers (11+12). This new grouping was necessary to ensure enough individuals were in each social group for meaningful analysis, but it largely maintains the character of the original HISCLASS scheme.

Grouping occupations in this way differentiates them more in terms of education, experience, and skill than by income per se. For instance, the elite group captures the most highly educated individuals who are, for example, judges, chemists, and engineers, while the lower manager group includes occupations such as archivists, foremen, and health inspectors. These two groups are largely comprised of white-collar workers, while the remaining three groups mainly contain manual or low-level retail workers. There was certainly heterogeneity in levels of income by occupation, such that an individual in the skilled worker group could potentially earn more than an individual in the elite group, though, on average, the groups do capture differences in income. Within the same occupation incomes could vary depending on employer or the location of one's work in the city, though the skills and experience required for the occupation should not have differed as much. Because many women exited the formal labor force after marriage, they would no longer have an occupational code assigned to them. Therefore, women were assigned their husband's occupation to approximate the social

[28] van Leeuwen, Maas, and Miles, *HISCO*.
[29] van Leeuwen and Maas, HISCLASS.

and economic resources they had at their disposal. In order to maintain a consistent definition of socioeconomic status in our analysis, only married women are discussed in this study.

Stockholm's male socioeconomic structure changed fairly little throughout the period. A slightly larger share of the population was identified as part of the upper classes by the 1920s than had been the case in the 1880s. At the outset, manual workers (i.e. the skilled, low skilled, and unskilled) made up about two thirds of all occupations and this number only declined slightly during the period. Some individuals had no occupation assigned to them and were thus coded as null occupations. At the start of the period they make up about 6 per cent of the sample, but by the end less than 2 per cent. This change seems to lie in the fact that data coverage in the earliest years of the system was still being refined.

All individuals had specific geographical variables assigned to them for their location within Stockholm and place of birth or migration destinations/origins. Because the borders of the districts changed over time within the city, it was necessary to make adjustments to maintain consistent geographical zones over time. The 36 districts of the Roteman's System have been redefined into seven time-invariant districts.

III

The period of 1878-1926 was one of great economic, social, and demographic change in Stockholm. After nearly a century of stagnant industrial wages and the migration of manufacturing industries southward to Norrköping, real wages of industrial workers increased dramatically starting in the 1850s and continued nearly unabated for the next 60 years.[30] This increase seems to predate the rise of real wages in many other European cities, which appear to have been modest until close to the turn of the twentieth century.[31] As economic prospects improved and access to railroad

[30] Lundh, Schön, and Svensson, 'Regional wages in Sweden', p. 66; Söderberg, 'Real wage trends', p. 157.
[31] Allen, 'European wage divergence'.

connections expanded, Stockholm's population grew tremendously at an annual rate of over 2 per cent from 1870-1930. Within this time frame, the city's population increased from about 136,000 inhabitants to over half a million. Population growth was so rapid, that the city struggled to provide adequate housing both in terms of quality and quantity. To address the excess demand for housing and the poor sanitary conditions of the city, the Lindhagen Committee developed a new city plan, which included strict building ordinances and regulation of the real estate market.[32]

As the surge in population took hold, fertility levels began a steady and dramatic decline in the 1880s. The timing and intensity of the decline in Stockholm closely coincides with fertility transitions observed in many European countries, including Sweden.[33] Figure 2 reveals a clear downward trend in the total marital fertility rate from age 20 (TMFR20) throughout the period.[34] The TMFR20 was near or above six births per married woman in all socioeconomic groups at the beginning of the period and, except for the unskilled, reached between two and three births by the end of the period. Already from the beginning of observation the upper classes had lower fertility rates than those of manual workers. The divide between upper and lower class marital fertility was large at the outset, with the elite group's fertility rates showing three fewer births than the unskilled. After an initial decline of about 1.5 births in the elite TMFR20 in the first decade of observation, there was a period of stagnation for about 25 years, while other groups continued their respective declines. The middle and lower classes saw large, sustained declines in period fertility and ultimately arrived at lower rates than the elite. By the final period, the only group with higher marital fertility than the elite was the unskilled.[35] The higher fertility of the elite is atypical of most populations in transition, though the general pattern of decline was in no way particular to Stockholm. In the rest of Sweden it appears that the elite also had lower fertility than other groups already in

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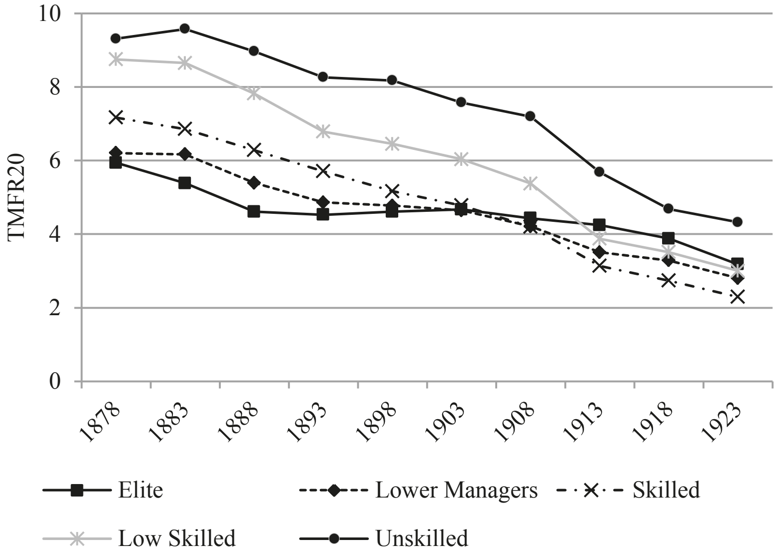
[32] Forsell, *Property, tenancy and growth*, p. 126.
[33] Coale and Treadway, 'Changing fertility distribution', p. 38.
[34] TMFR20 is a hypothetical measure of the number of children a married woman would have if she followed the period age-specific marital fertility rates of the given time frame with full exposure. It should not be interpreted as average completed fertility rates.
[35] Edin and Hutchinson, *Differential fertility*; Hutchinson, 'Education and intramarital fertility', provide contemporary accounts which also identified this unique pattern for Stockholm.

1880, while the middle classes converged to similar levels around 1900.[36] Furthermore, recent evidence has shown this to be a common pattern between occupational groups in rural Europe and North America during populations' respective fertility transitions.[37]

Figure 2. Total marital fertility rate from age 20 (TMFR20) by socioeconomic status



Notes: TMFR20 is the hypothetical number of births a married woman would have had between the ages of 20 and 49 if she had experienced the same age-specific marital fertility rates that were present in the period and remained married until at least 49 years old. Age-specific rates calculated per woman-year.

Source: Roteman Database.

In purely mechanical terms, any differences in fertility between groups should be attributable to either differences in the timing of first births, time between births, or the termination of childbearing. Because information on marriage dates is missing from the data, the entry into motherhood can only

[36] Dribe and Scalone, 'Social class and net fertility'.
[37] See Bengtsson and Dribe, 'Fertility transition in Southern Sweden'; Vézina, Gauvreau and Gagnon, 'Fertility differentials in Quebec'; Maloney, Hanson and Smith, 'Frontier fertility'; Breschi, et al., 'Fertility and stratification in Sardinia'.

be observed with absolute certainty for women who are present in the data from age 18 until age 50. Restricting the sample in this way revealed that the mean age at first birth for almost all socioeconomic groups remained virtually constant for the cohorts born in 1860-76. It was only among the unskilled that there was a clear change over time; the mean age at first birth decreased for this group, which should have no fertility limiting implications. Furthermore, the mean age was remarkably similar across socioeconomic groups and cohorts, only varying by about six months for any given cohort.

The time between births seems not to have played much of a role in generating fertility differences in Stockholm either, as birth intervals were similar between groups both in the cross-section and over time.[38] The similarity of birth intervals between occupational or social groups seems to be typical of populations in transition and Stockholm is no different in this regard.[39] They consistently increased throughout the period among all groups, starting at 24 months in 1878-82 and increasing to more than 36 months by 1923-6. This ubiquitous and nearly identical increase in birth intervals for different classes demonstrates period effects on fertility, but would not lead to such extensive differences in total fertility between groups.

The termination of childbearing differed much more between classes than the length of birth intervals or the entry into motherhood. At the beginning of our period of observation, the elite tended to end childbearing significantly earlier than other groups, having a mean age at last birth of about 32 years old. Manual workers from the skilled and unskilled classes ended childbearing about three to four years later on average. Interestingly, the age of stopping childbearing changed very little for the elite throughout the fertility transition, while other groups saw large reductions during the period. By the end of our observation, there were virtually no differences in the mean age at last birth between groups. This has been found in other populations as well,[40] and provides evidence that differences the timing of

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[38] Here, birth intervals refer to the time between two births. That is, only intervals that end with a birth are included in this calculation, while the time following the last observed birth is excluded.

[39] Vézina, Gauvreau and Gagnon, 'Fertility differentials in Quebec'; Maloney, Hanson and Smith, 'Frontier fertility'; Breschi, et al., 'Fertility and stratification in Sardinia'.

[40] Bras, 'Structural and diffusion effects'; Vézina, Gauvreau and Gagnon, 'Fertility differentials in Quebec'.

fertility decline between classes were related to differential adoption of fertility control.

While the preceding statistics provide a necessary overview of the fertility transition, they leave the picture incomplete. For instance, they do not take into account important factors such as child survivorship, which may have a profound impact on decisions to lower fertility. In order to better assess how socioeconomic groups began to regulate their fertility, we turn to multivariate event-history techniques, where we can control for factors that may distort period differences across groups.

IV

To identify class differences in the fertility transition, we use event-history models to estimate differences in the risks of continued childbearing (i.e. fertility beyond the first birth) across groups and then use logistic regression to identify differences in the adoption of stopping behavior. Event-history techniques are invaluable when working with longitudinal data, as they allow for taking into account the fact that not all individuals are exposed to childbearing at all times due to censoring from mortality, migration, or other reasons. Furthermore, they can easily handle time-varying covariates, thereby allowing for a fuller use of the data than cross-sectional approaches.

The women included in the analysis had to have been between the ages of 15 and 49 and married. Furthermore, women were not considered to be at risk for continued childbearing until they had one *observed* birth within the city. For example, if a woman entered the city at age 25, she would not be considered at risk until she had her first marital birth in Stockholm. This requirement is meant to ensure that we only are observing women who had already begun their childbearing, as individuals who migrated to the city after age 15 may or may not have already had children. Censoring women before reaching age 50 was very common, amounting to over 90 per cent of individuals. This is not unexpected as we only consider a 48-year period and every woman reaching age 15 after 1891 cannot be observed reaching age 50 regardless of whether or not she remained in the city.

A woman fell out of observation if one of the following occurred: migration out of the city, termination of marriage, reaching age 50, death, or the end of the ledger period was reached (i.e. 31 December 1926). Migration within Stockholm's digitized districts would not result in censoring, though migration to a district that has not been digitized would. Of all censored individuals, those moving to a non-digitized district amount to 25 per cent, those moving out of the city entirely were 20 per cent, deaths led to the censoring of about 5 per cent, and the termination of marriage censored about 10 per cent. The rest of those not observed until age 50 were censored due to the ending of the ledger period.

The reasons for the termination of a marriage are not always entirely clear. 36 per cent of the women being censored for this reason became widows, while 10 per cent divorced. The rest were simply listed as unmarried again, but without an explanation of the cause. Based on the mortality information of husbands it appears that roughly half of these women were actually widows, but simply listed as single. If women re-married and had a child, they once again became at risk of marital fertility. About 5 per cent of the women in the sample re-married at least once. It is sometimes possible to identify non-marital cohabitation between, for example, a servant or lodger and a head of household, but only when they had children. In the majority of cases, however, the relationship is not clear and correctly identifying the population at risk would be nearly impossible. For this reason, cohabitants are excluded from the analysis. In addition to the above restrictions, women were also censored if an interval was eight years or longer. This restriction is meant to crudely identify intentional versus accidental spacing or failed stopping and also serves to eliminate the possible influence of the under-recording of births.

After determining the risk population, we implemented piecewise constant hazard models to estimate socioeconomic differences in the risk of a mother having additional children beyond her first when holding other covariates constant.[41] In practice, this means that we do not assume the fundamental risk of having another child follows any particular pattern for a married woman over time, which could lead to biased estimates if we artificially imposed an incorrect form. Instead, we allow the data to tell us at what points in time baseline risks of a birth are higher or lower by assigning dummy variables for periods of analysis-time. In these models, we include

[41] Laaksonen et al., 'Estimation', p. 838, explain that the piecewise constant model can approximate virtually any baseline hazard function without making incorrect assumptions as to its form.

dummies for six-month periods starting from the time a woman becomes at risk of having an additional birth (i.e. by having her first observed birth in the city) until she is censored or has another birth.[42] In order to account for the fact that some women may be more or less fertile for unobserved reasons, we include a shared frailty term in our models at the mother level, which is analogous to controlling for mother-specific random effects.

The main covariates of interest were socioeconomic status, a categorical period variable, and their interaction effects. Controls used in the model were mother's birthplace, location within the city, a dummy indicating if the previous child born died within two years, the mother's age, the observed interval, and the number of surviving children observed in the household. All covariates except for the mother's birthplace and observed interval are time-varying within each birth interval. In the case of the survival status of the previous child, if the previous child died this dummy would be coded as one if the child died within two years of birth and then zero after two years from the death of that child.[43] This is meant to account for births that may be 'replacing' the previously lost child either due to parental preference or the biological increase in fecundity that occurs when breastfeeding is truncated.[44] The number of surviving children observed in the household is also time-varying, so that if, for example, any child dies during the interval, this value will decrease. In total, the analysis sample included over 77,000 mothers and more than 91,000 births. Table 1 provides descriptive statistics of the models' covariates.

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[42] Six-month time pieces provide a more detailed fit than using one-year time pieces, but it also does not require the estimation of a large amount of intercepts as would be the case when using monthly breaks. Estimations of the model using one-month and one-year time pieces were also performed, but provided virtually identical results.
[43] This definition is also employed by Tsuya, Feng, and Alter, eds., *Prudence and pressure*, in their analyses of fertility in rural communities throughout Europe and Asia.
[44] Bongaarts, 'Proximate determinants of fertility'.

Table 1. Distribution of covariates for piecewise constant hazard and logistic regression models

	Continued childbearing model[a]	Stopping model[b]
Socioeconomic status:		
Elite	6.1	6.7
Lower managers	20.8	20.6
Skilled Workers	28.2	29.4
Lower skilled	20.7	20.7
Unskilled	23.1	21.6
Null	1.1	1.1
Period:		
1878-1882	3.6	9.0
1883-1887	7.9	12.0
1888-1892	9.9	12.4
1893-1897	10.7	11.8
1898-1902	11.5	12.2
1903-1907	11.3	11.5
1908-1912	11.2	10.9
1913-1917	12.5	10.7
1918-1922	13.0	9.4
1923-1926	8.3	
District:		
Gamla Stan	4.6	4.7
Norrmalm	9.6	10.7
Östermalm	16.4	16.5
Kungsholmen	22.4	22.9
Södermalm-East	23.3	23.1
Södermalm-West	19.5	19.4
Brännkyrka	4.3	2.7

(continued on next page)

Table 1 (continued)

	Continued childbearing model[a]	Stopping model[b]
Mother's Birthplace:		
Stockholm city	24.7	24.1
Stockholm county	11.6	11.5
Other Sweden	60.0	60.5
Outside Sweden	3.2	3.3
Not defined	0.5	0.6
Previous child dead within two years	7.8	8.2
Mother's age:		
15-19	0.2	0.7
20-24	5.9	13.9
25-29	20.1	29.8
30-34	26.7	28.3
35-39	23.3	19.3
40-44	16.0	8.0
45-49	7.7	
Surviving observed births[c]:		
0	3.2	
1	41.3	36.4
2	25.9	26.5
3	14.3	16.3
4	7.6	9.4
5	3.9	5.3
6	2.0	2.9
7+	1.9	3.2

(continued on next page)

Table 1 (continued)

	Continued childbearing model[a]	Stopping model[b]
Birth Interval		
1	38.3	36.3
2	24.1	25.0
3	14.8	15.5
4	9.1	9.4
5	5.6	5.7
6	3.5	3.5
7+	4.6	4.6
Mothers	77,247	67,393
Failures	91,779	44,666
Person-years at risk/intervals[d]	551,170.8	147,453

Notes: Figures refer to distribution of categories within each variable.

[a] woman became at risk of continued childbearing after having one observed birth in the city.

[b] excludes women who were aged about 45 years old and those who experienced a birth after 1921

[c] number of surviving births cannot equal zero for stopping model, as it refers to the number of children at the start of an interval

[d] Person-years are reported for the model of continued childbearing while the number of intervals are reported for the stopping model

Source: Roteman Database.

Based on the above specification, three models were estimated to understand this association. The first was a basic model with only the socioeconomic group and period dummies as independent variables. The second was an extended model with the same independent variables and with the addition of the mother's birthplace, survival status of the previous birth, location within the city, mother's age, interval order, and net parity as controls. Finally, an interaction model was run with the same set of variables as in the extended model, plus an interaction of period and socioeconomic status to see how the association of class and fertility evolved over time. The results of the basic and extended models can be found in table 2.[45]

The basic model indicates that the low skilled and unskilled groups were the most likely to have additional children after their first birth, while the skilled and lower managers were the least likely. The elite fell between these groups. As we would expect during the transition, the likelihood of having additional children fell as the period progressed, so that women in 1878-82 were more than three times as likely to have an additional child as women in 1923-1926, when controlling for social class. After extending the model by incorporating the aforementioned controls, the pattern across socioeconomic groups became more clearly delineated. The wives of low skilled and unskilled workers were 30 to 40 per cent more likely to have additional children than the elite during the entire period, while those of skilled workers were about 11 percent more likely. In both models all socioeconomic groups' coefficients were significantly different from the reference group (i.e. elite) at the 1 per cent level.

Table 2. Piecewise constant hazard models of continued childbearing with maternal frailty

	Basic model[a]		Extended model[b]	
	HR	p-value	HR	p-value
Socioeconomic status:				
Elite[c]	1.00		1.00	
Lower managers	0.89	0.000	0.94	0.006
Skilled Workers	0.94	0.000	1.11	0.000
Lower skilled	1.09	0.000	1.29	0.000
Unskilled	1.08	0.000	1.37	0.000
Null	1.05	0.200	1.50	0.000

(continued on next page)

[45] The results are presented as hazard ratios. These may be thought of as the instantaneous ratio of incidence rates between a group and its reference group. In other words, a hazard ratio of 2.0 could be interpreted as a group having twice the birth rates of the reference group at any point in analysis-time.

Table 2 (continued)

	Basic model[a]		Extended model[b]	
	HR	p-value	HR	p-value
Period:				
1878-1882[c]	1.00		1.00	
1883-1887	0.98	0.211	1.04	0.042
1888-1892	0.84	0.000	0.91	0.000
1893-1897	0.73	0.000	0.80	0.000
1898-1902	0.68	0.000	0.73	0.000
1903-1907	0.64	0.000	0.68	0.000
1908-1912	0.57	0.000	0.59	0.000
1913-1917	0.44	0.000	0.43	0.000
1918-1922	0.36	0.000	0.36	0.000
1923-1926	0.29	0.000	0.29	0.000
Controls for:				
Mother's birthplace			x	
Survival status of previous child			x	
Mother's age			x	
Number of surviving children			x	
Birth Interval			x	
Individuals	77,247		77,247	
Intervals	172,997		172,997	
Failures	91,779		91,779	
Time at risk	551,170		551,170	
Chi2	223,001	0.000	153,682	0.000

Notes: Assumes a piecewise constant hazard for six month periods and assumes a mother-specific frailty term that follows the inverse-Gaussian distribution. Coefficients presented as hazard ratios. A hazard ratio of 0.5 would indicate that an individual with that characteristic had roughly half the chance of having an additional child at any point in time.

[a] only includes socioeconomic status and a period trend

[b] includes controls for maternal characteristics and child mortality

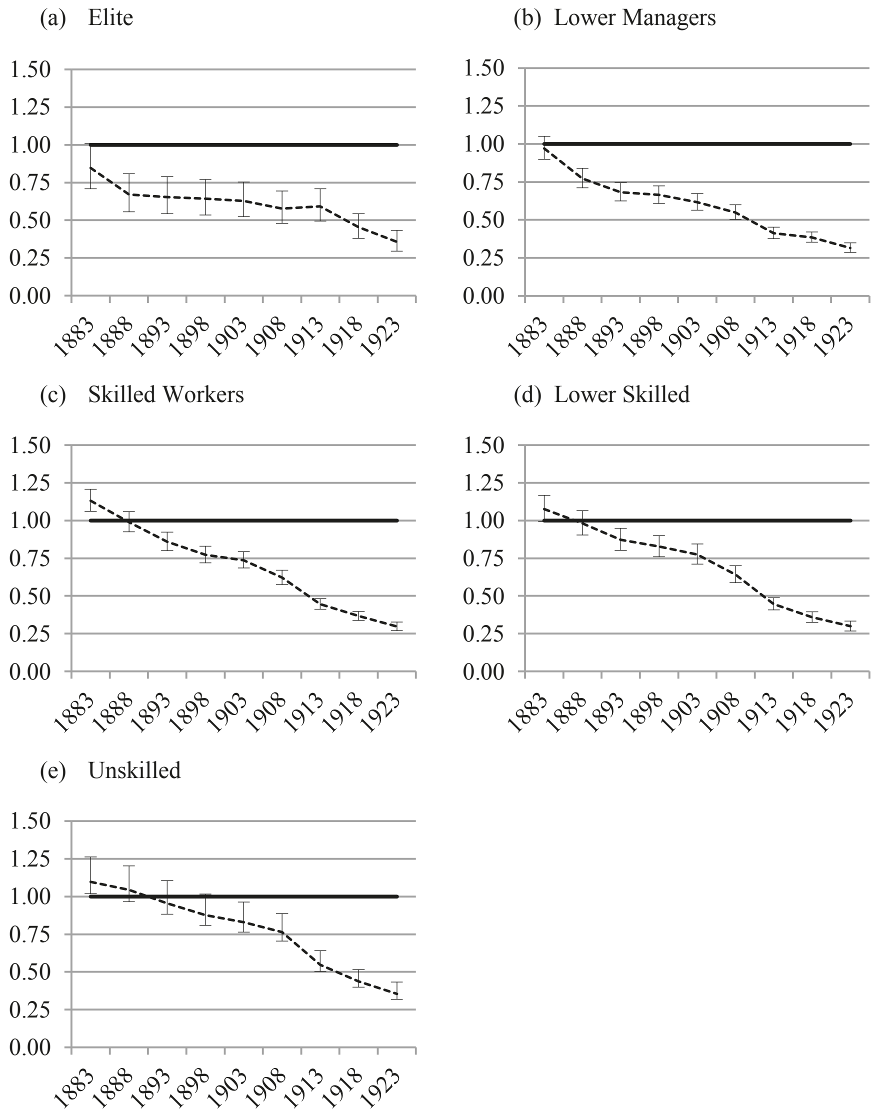
[c] serves as the reference category

Source: As for tab. 1.

In order to see how these associations changed over time, an interaction term of period and socioeconomic status was included in the extended model. Figure 3 shows the changes in fertility within each group over time (presented as hazard ratios) with the first period serving as the reference category. In this case, a decrease in the hazard ratio below 1 indicates lower fertility than the first period. Unsurprisingly, fertility declined for all groups throughout the period. But early on, the white collar groups showed declines in fertility while manual workers showed no statistical difference compared to the period 1878-82. Shortly thereafter the elite fertility decline slowed while other groups continued their declines more rapidly. The unskilled were laggards in the process, showing no significant decline in fertility until the turn of the twentieth century. By 1913-7 all groups but the elite were about half as likely to have additional births as they were at the start of the decline, and by 1923-6 all classes had reduced their fertility by a factor of three or more.

For a fuller view, we look at the differences between groups over the period with the elite serving as the reference group in figure 4. In this figure, a hazard ratio above one indicates larger differences in fertility between a group and the elite. Here it is clear that differences in class fertility widened substantially early in the fertility transition. At the start of our period, the highest fertility group (i.e. the lower skilled) had about 40 per cent higher fertility than the elite. Only ten years later the gap had nearly doubled and gradually declined thereafter. As figure 6 indicated, the widening differentials are mainly due to the rapid decline in elite fertility at the start of our period, rather than higher fertility among the lower classes. What is remarkable is the clear pattern of convergence between classes over time. The difference between the two white collar groups was reduced quickly, while the fertility of the working classes did not arrive at the same level as the elite until several decades later. Furthermore, the equalization of fertility between groups came in spite of the fact that child mortality continued to disproportionately affect the working classes.

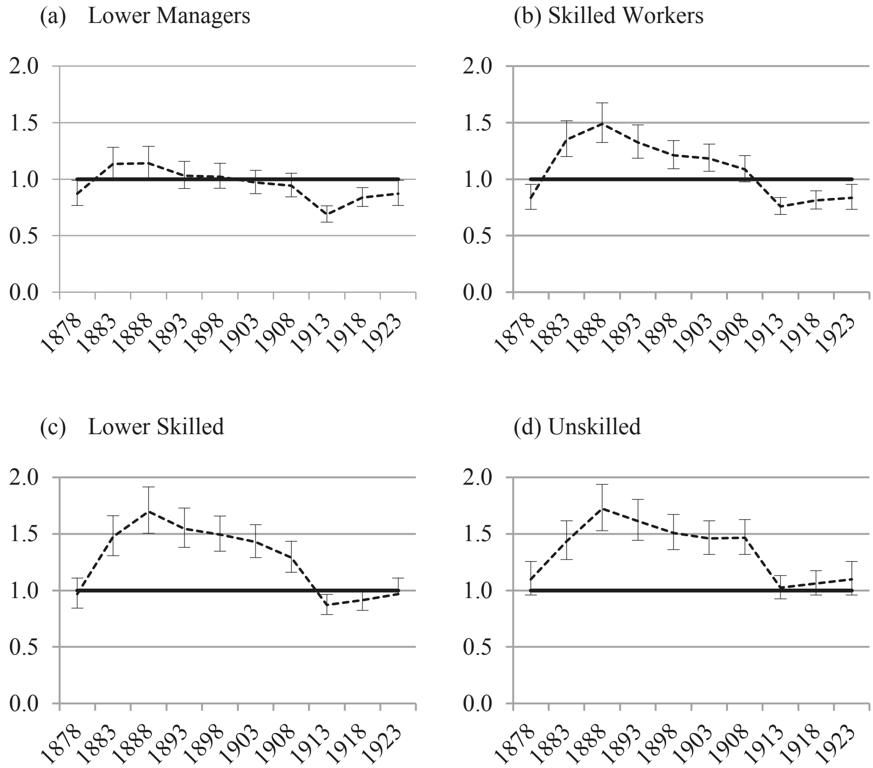
Figure 3. Net change in continued childbearing risks within socioeconomic groups.



Notes: Changes are presented as hazard ratios in relation to the fertility observed in the period 1878-82 (solid line). Error bars represent 95 per cent confidence intervals and indicate statistical significance from fertility levels in 1878-82. Null occupations were included in the models, but the results are not shown here.

Source: As for fig. 2.

Figure 4. Differences in continued childbearing risks between socioeconomic groups.



Notes: Differences between groups presented as hazard ratios in relation to the fertility of the elite (solid line). Error bars represent 95 per cent confidence intervals and indicate statistical significance from elite fertility levels in each period. Hazard ratios below 1 indicate a lower risk of having children beyond the first compared to the elite. Null occupations were included in the models, but the results are not shown here.

Source: As for fig. 2.

So far, the results neither address how this behavior was achieved nor why the ordering of class fertility would have changed. By examining class differences in women's stopping behavior, we can observe the differential adoption of contraceptive methods between groups.[46] To accomplish this, the termination of childbearing was estimated using logistic regression.[47] The dependent variable in this model is the probability of experiencing a birth interval that is five years or longer, as it is uncommon for a birth to follow an interval of this length.[48] The unit of analysis is the birth interval, and the method utilizes nearly the same sample as in the event-history model, but with some slight differences. Because of how this outcome is defined, the oldest a mother could be at the start of an interval was 44 years old and the latest year an interval could begin was in 1921.[49] To account for failed stopping, all intervals that are five years or longer and are followed by another birth are not considered as stopping. Intervals ending because of migration, marriage termination, or death are excluded from this analysis.

The covariates were the same as in the previous models but defined slightly differently. In the stopping model, socioeconomic status refers to the highest status attained during the interval. Period refers to the time at which the interval began. Mother's age refers to her age at the start of the interval. The number of surviving children refers to the number of children alive at the start of the interval and the survival status of the previous child indicates whether or not that child died within two years. To account for intragroup correlation across intervals standard errors were clustered by mother.

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[46] 'Contraceptive methods' refers to both 'natural' (e.g., withdrawal, abstinence) and 'artificial' (e.g., condoms, sponges) forms of contraception as we are unable to distinguish between the two in our analysis.

[47] van Bavel, 'Diffusion effects', p. 69, uses a similar model to analyse stopping behavior in Antwerp.

[48] Larsen and Menken, 'Measuring sterility', p.188.

[49] Although the maternal age distribution is truncated by five years, this should not influence the results much, as birth rates above age 45 were extremely low throughout the whole of the period.

The results of the logistic regression (shown in table 3) indicate a large gap between the upper classes and the rest with respect to stopping behavior. The odds of stopping were significantly higher among the elites and lower managers compared to the middle and lower classes. As one would expect, those with the highest fertility for most of the period (i.e. the unskilled) were also the least likely to end their childbearing at any given interval and increasing period effects indicate a general growth in practicing fertility control for all.

The full interaction model shows that the elites experienced relatively little change in their stopping behavior over time (figure 5), suggesting that they had already been limiting fertility considerably early on.; the net-increase in stopping behavior was about 75 per cent for this group and 150 per cent for the lower mangers. Yet these numbers pale in comparison to the change experienced by members of the skilled, low skilled, and unskilled groups, which amounted to roughly a fourfold increase in fertility limitation. Until the end of the nineteenth century, the successful adoption of contraception was gradual among these groups, and the largest increases in stopping behavior among the working classes occurred well after child mortality had begun its decline.

Comparing classes we can see significant differences in the adoption of fertility control (figure 6). The elite were by far the most likely to exhibit this behavior from the outset, and were the most likely to do so for the first two decades under observation. This difference may explain why there was relatively little change in their stopping behavior throughout the period. The lower managers also were early adopters, showing relatively small differences from the elite and matching the elite by the last decade of the nineteenth century. The middle and lower classes, on the other hand, were less than half as likely to limit fertility early at the start of the period, and this difference remained more or less constant until near the end of the century. These groups showed nearly identical patterns in stopping behavior and it was not until thirty years after the start of our period that the skilled and low skilled had reached the same level of fertility limitation as the elite. The unskilled were the laggards in the process, becoming the last to reach the elite level of fertility regulation. By the end of the period, there was no statistical difference in stopping behavior between socioeconomic groups.

Table 3. Logistic regression of probability of having a five-year birth interval.

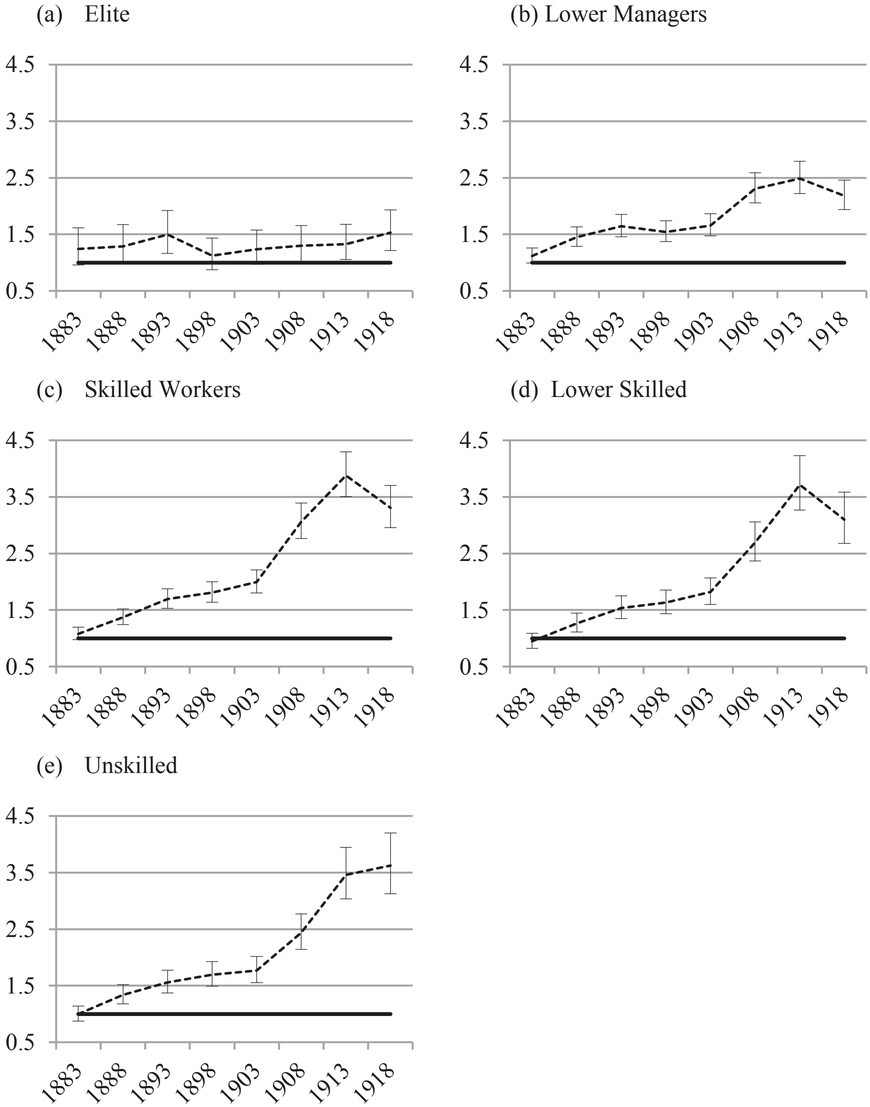
	Basic model		Extended model	
	OR	p-value	OR	p-value
Socioeconomic status:				
Elite[a]	1.00		1.00	
Lower managers	1.31	0.000	1.23	0.000
Skilled Workers	1.10	0.000	0.96	0.099
Lower skilled	1.00	0.847	0.89	0.000
Unskilled	0.86	0.000	0.70	0.000
Null	0.74	0.000	0.57	0.000
Period:				
1878-1882[a]	1.00		1.00	
1883-1887	1.05	0.071	1.05	0.101
1888-1892	1.33	0.000	1.32	0.000
1893-1897	1.60	0.000	1.56	0.000
1898-1902	1.63	0.000	1.59	0.000
1903-1907	1.74	0.000	1.74	0.000
1908-1912	2.36	0.000	2.48	0.000
1913-1917	3.01	0.000	3.05	0.000
1918-1921	2.77	0.000	2.71	0.000
Controls for:				
Mother's birthplace			x	
Survival status of previous child			x	
Mother's age			x	
Birth Interval			x	
Number of surviving children			x	
Individuals	67,393		67,393	
Intervals	147,453		147,453	
Chi2	4,358		11,747	
Pseudo R2	0.026		0.079	

Notes: Coefficients are presented as odds ratios. Standard errors clustered by mother.

[a] serves as the reference category.

Source: As for tab. 1.

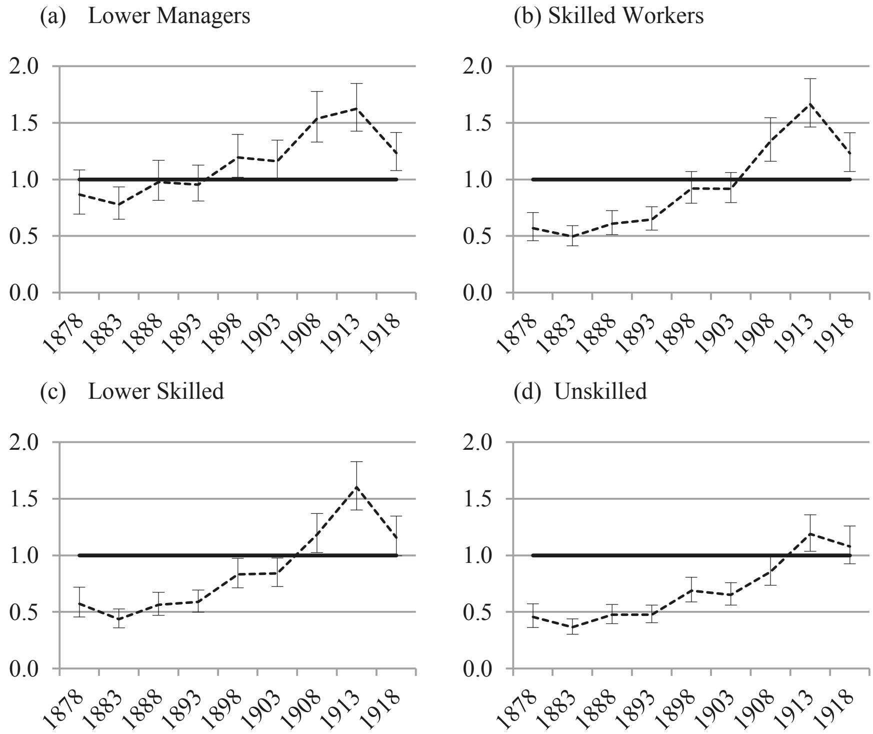
Figure 5. Net change in stopping behavior within socioeconomic groups.



Notes: Changes are presented as odds ratios in relation to the level of stopping behavior observed for intervals beginning in the period 1878-82 (solid line). Error bars represent 95 per cent confidence intervals and indicate statistical significance from stopping levels in 1878-82. Null occupations were included in the models, but the results are not shown here.

Source: As for fig. 2.

Figure 6. Differences in stopping behavior between socioeconomic groups.



Notes: Elite serves as the reference group for all sub-periods. Changes are presented as odds ratios in relation to the level of stopping behavior observed for the elite in each period (solid line). Error bars represent 95 per cent confidence intervals and indicate statistical significance from elite fertility levels in each period. An odds ratio of 1.5 would indicate that a group was about 50 per cent more likely to end their childbearing early than the elite. Null occupations were included in the models, but the results are not shown here.

Source: As for fig. 2.

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This paper has provided a rare view of an urban fertility transition using individual-level occupational and demographic data, a description that has been lacking from the literature, yet may hold the key to understanding the potential causes of the decline. We have shown that it was the upper classes who were the leaders of the decline, which is highly consistent with individual-level research covering rural transitions.[50] Already from the outset, they were much more likely to limit their fertility after any given birth than the lower classes and they were the first socioeconomic group to show any statistically significant decline in higher-order fertility. The industrial working classes, on the other hand, were later in reducing their fertility, but once the first signs of decline were apparent they did so at a much faster pace than the elite. As the transition proceeded, all other groups began to demonstrate similar patterns of fertility control, and by the end of our period of observation, the elite actually had relatively high fertility.

While this study has not explicitly tested theories of the decline, it is worthwhile to discuss how the class-specific patterns shown for Stockholm relate to some of the major hypotheses found in the literature. That the decline first started among high-status groups calls into question some common explanations for the transition that emphasize the growing direct and indirect costs of children. In terms of direct costs, most historical trends would suggest that children generally became more expensive for the lower classes rather than the elite in relative terms. The expansion of mandatory primary education would have certainly exerted a greater burden on working-class families than the elite and, even then, probably only for the poorest families who not only would have needed to finance their children's school supplies, but also may have lost a potential source of income. The costs of education in Stockholm were so low at the start of the fertility transition that the city had already achieved over 90 per cent enrollment of the school-age population by 1882.[51] Increases in the direct costs of children via a rising cost of living also do not seem to fit the patterns observed here. During much

[50] Footnote 10.
[51] Statistics Sweden, *Undervisningsväsendet*, pp. 10-1, The enrollment rate was calculated from the statistics presented in table 4.

of our period of observation the cost of food, clothing, and fuel were generally declining in Stockholm, while at the same time wages for skilled and unskilled industrial workers were continually increasing.[52] It was only after the First World War that these items became significantly more expensive. The only substantial increases in the cost of living during the period came in the form of higher rents, but these seem to have increased more or less uniformly for flats of most sizes. Between 1894 and 1920, average rent increased by about 125 per cent for most apartments,[53] but only by about 70 per cent for the largest flats in Stockholm (more than 6 rooms), suggesting that, while nominal living costs were growing for all, they grew at a significantly slower rate for those residing in the highest priced real estate in the city. As for indirect costs, female labor force participation among married women in Stockholm was largely concentrated in the lower classes, as it appears to have been in other historical populations,[54] suggesting substantially higher opportunity costs of childbearing for these women and, presumably, a greater motivation to limit fertility.

We do not claim that economic changes were unimportant in stimulating the fertility decline, but rather that some of the leading explanations do not fit very well to the patterns observed. Instead, attention needs to be refocused on economic changes that may have disproportionately influenced the behavior of the upper classes. For instance, it has been argued in recent years that fertility may have declined as a response to a rising demand for human capital.[55] This could very well be consistent with an early decline of elite fertility if those parents were more able and willing to invest in their children's education beyond requisite levels earlier in the industrialization process. Given that enrollment in higher education was still extremely low during this period in Swedish history,[56] the majority of children attending secondary schools and universities probably would have largely originated from the upper social strata. But this hypothesis requires much more evidence of a tradeoff among the higher classes between family size and children's human capital investments in a historical context.

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[52] Lundh, Schön, and Svensson, 'Wage formation', pp. 84-9.
[53] Stockholm Stads Statistiska Kontor, *Statistisk Årsbok för Stockholms Stad 1925*, p. 89.
[54] Footnote 20.
[55] Galor, *Unified growth*; Galor and Moav, 'Natural selection and the origin of economic growth'; Galor and Weil, 'Population, technology and growth'.
[56] Statistics Sweden, *Elever i Icke-Obligatoriska Skolor*.

The class differences observed in the timing of the decline, levels of fertility, and practicing of stopping behavior seem to be consistent with two other explanations: differences in child mortality and differential acceptance of fertility control. Already at the start of observation, infant mortality rates among children of the unskilled were three times larger than those of the elite,[57] and this had a clear impact on fertility. Our models explicitly controlled for the number of surviving offspring and whether or not the previously-born child had died within two years. The death of the previously-born child was consistently associated with an elevated risk of childbearing throughout the period, a finding that has been repeatedly observed in historical demographic studies in a variety of contexts.[58] There were no statistically significant differences in this association between socioeconomic groups. Figure 7 shows the proportion of births occurring within two years of the death of the previous child, reflecting both a higher physiological propensity to have children and probably also a degree of parental choice to replace lost children. For the working classes, there was remarkably high child replacement at the start of the period. Almost a third of all births to the unskilled followed the death of the previously born child, while the elite saw rapid declines in this proportion early on. By 1926, there were only small differences between social groups.

Because there was no difference in how the fertility of the elite responded to child mortality compared to other groups, the early differences in fertility may have been driven by differential child survival. That the children of the elite were less likely to die prematurely meant that, on average, they needed to have fewer births in order to reach a desired family size and it is likely that this was a major incentive that led to the differential stopping behavior observed early in the transition. This hypothesis cannot explain, however, why the socioeconomic ordering of fertility changed near the end of the transition, when a class gradient in mortality still persisted.

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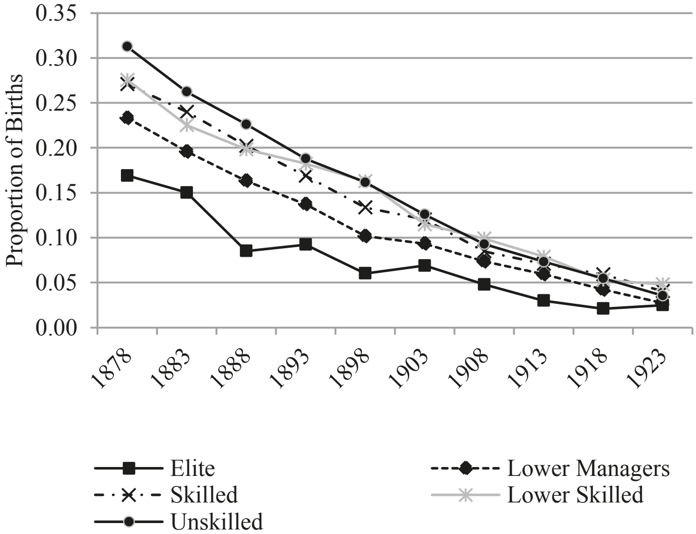
[57] Burström et al., 'Water and sanitation'.

[58] See for examples, Tsuya, Feng, and Alter, eds., *Prudence and pressure*.

Figure 7. Proportion of all births following the death of the previous child by socioeconomic status.



Notes: Births were considered to have followed a previous child's death if they occurred within two years of the date of death and the previous child died within two years of being born.

Source: See section II.

A complementary explanation for these patterns is that elite groups had a greater ability to control their fertility either because they had access to better contraceptive information or technology or their social environment was more accepting of family limitation. Proving either of these is difficult, as data on contraceptive attitudes and usage are virtually non-existent for most historical populations. But the lagged increase in stopping behavior and its convergence across groups by the end of the transition is at least consistent with an emergence and spread of new contraceptive methods or norms. Some evidence suggests that members of Stockholm's intelligentsia were deeply involved in neo-Malthusian movements which aimed to disseminate literature on contraception.[59] For example, the membership roll of one organization, the Swedish Association for the Protection of Mothers

[59] See Levin, *Masken,* for a discussion of the Swedish neo-Malthusian movement in the late nineteenth century.

and Sexual Reform, included prominent members of Stockholm society, such as Carl Lindhagen, Stockholm's Chief Magistrate, and Jakob Pettersson, the mayor of nearby Södertälje, as well as medical practitioners, academics, and business owners. Furthermore, the Swedish anti-contraception law of 1910, *Lex Hinke*, specifically warns physicians against advising their patients in sexual matters under the threat of fines and imprisonment, indicating the presence of asymmetrical knowledge of contraception and attempts to disseminate such information. But aside from such fragmentary evidence, it is unclear as to how widespread the use of artificial contraceptives actually was in any segment of society. Evidence from other countries suggests that traditional methods (i.e. abstinence and withdrawal) remained the main forms of birth control practiced during the fertility decline,[60] and there is a growing body of work showing that the ability to efficiently regulate fertility was present in pre-transitional populations, possibly even since antiquity.[61] Perhaps the social activism by members of the elite is more demonstrative of their viewing fertility limitation as an acceptable and reasonable behavior rather than as an illustration of superior knowledge, and that it was diffusion of these ideas that prompted lower fertility. But this interpretation too is not without its problems, as it was also members of the elite who explicitly imposed the outright ban on the distribution contraceptive literature in 1910. The role of ideational diffusion may be consistent with the patterns observed in Stockholm and other populations, but it needs more systematic, empirical work to demonstrate that the elite indeed held more liberal views towards contraception and that these were transferred to the rest of the population.[62]

This paper has contributed to the growing body of individual-level research that has shown an early fertility decline among high-status groups, an aspect of the transition that cannot be ignored when discussing its causes. This particular pattern seems to be consistent with the respective declines in

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[60] David and Sanderson, 'Rudimentary contraceptive methods in America'; Szreter and Fisher, 'Birth control and abstinence in England'.
[61] Dribe and Scalone, 'Detecting deliberate fertility control'; Dribe, 'Demand and supply factors'; Bengtsson and Dribe, 'Deliberate control'; Kolk, 'Birth Spacing in Northern Sweden'; van Bavel, 'Deliberate birth spacing'; McLaren, *History of contraception*; Santow, 'Coitus interruptus'.
[62] Gonzalez-Bailon and Murphy, 'Effects of social interactions on fertility', have shown through simulations that the French fertility decline can be replicated by incorporating a role for social interactions.

child mortality among the socioeconomic groups and may also reflect differential access to contraception, either in the form of modern birth control methods or in social acceptance within their circles. These findings also cannot rule out the possibility that fertility fell as a response to a rising demand for human capital. This study is limited, however, in that it has not empirically tested these hypotheses. If we are to gain a better understanding of the explanatory factors behind the process, more detailed, individual-level work is needed to understand exactly how these forerunner groups differed from the rest of the population in terms of their motivation, willingness, and ability to regulate their fertility.

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Appendix

Below are the full results of the piecewise constant hazard model and logistic regression.

Table 1A. Models of continued childbearing and stopping with full reporting of control variables.

	Continued childbearing		Stopping model	
	HR	p-value	OR	p-value
Socioeconomic status:				
Elite[a]	1.00		1.00	
Lower managers	0.94	0.006	1.23	0.000
Skilled	1.11	0.000	0.96	0.099
Low skilled	1.29	0.000	0.89	0.000
Unskilled	1.37	0.000	0.70	0.000
Null	1.50	0.000	0.57	0.000
Period:				
1878-1882[a]	1.00		1.00	
1883-1887	1.04	0.042	1.05	0.101
1888-1892	0.91	0.000	1.32	0.000
1893-1897	0.80	0.000	1.56	0.000
1898-1902	0.73	0.000	1.59	0.000
1903-1907	0.68	0.000	1.74	0.000
1908-1912	0.59	0.000	2.48	0.000
1913-1917	0.43	0.000	3.05	0.000
1918-1922	0.36	0.000	2.71	0.000
1923-1926	0.29	0.000		

(continued on next page)

Table 1A (continued)

	Continued childbearing		Stopping model	
	HR	p-value	OR	p-value
District:				
Gamla Stan[a]	1.00		1.00	
Norrmalm	1.09	0.000	0.80	0.000
Östermalm	0.47	0.000	1.16	0.000
Kungsholmen	0.70	0.000	0.98	0.635
Södermalm-East	0.53	0.000	1.16	0.000
Södermalm-West	0.58	0.000	1.16	0.000
Brännkyrka	0.22	0.000	1.38	0.000
Mother's Birthplace:				
Stockholm city[a]	1.00		1.00	
Stockholm county	1.02	0.165	0.92	0.001
Other Sweden	1.05	0.000	0.89	0.000
Outside Sweden	1.03	0.246	0.82	0.000
Not defined	0.63	0.000	0.73	0.000
Previous child dead within two years	1.41	0.000	0.62	0.000
Mother's age:				
15-19[a]	1.00		1.00	
20-24	0.49	0.000	1.32	0.002
25-29	0.31	0.000	1.77	0.000
30-34	0.22	0.000	2.35	0.000
35-39	0.16	0.000	3.93	0.000
40-44	0.08	0.000	10.49	0.000
45-49	0.01	0.000		

(continued on next page)

Table 1A (continued)

	Continued childbearing		Stopping model	
	HR	p-value	OR	p-value
Surviving observed births:				
0	7.22	0.000		
1[a]	1.00		1.00	
2	1.13	0.000	1.12	0.467
3	1.19	0.000	1.14	0.399
4	1.33	0.000	1.12	0.466
5	1.42	0.000	1.16	0.332
6	1.68	0.000	1.15	0.382
7+	1.91	0.000	1.00	0.991
Birth Interval:				
1[a]	1.00		1.00	
2	0.68	0.000	1.18	0.000
3	0.59	0.000	1.13	0.000
4	0.53	0.000	1.07	0.072
5	0.50	0.000	0.97	0.506
6	0.45	0.000	0.88	0.012
7+	0.42	0.000	0.72	0.000
Constant			0.10	0.000
Individuals	77,247		67,393	
Intervals	172,997		147,453	
Failures	91,779			
Time at risk	551,170			
Chi2	153,682	0.000	11,747	0.000

Notes: Continued childbearing model assumes a piecewise constant hazard for six month periods and assumes a mother-specific frailty term that follows the inverse-Gaussian distribution. Coefficients presented as hazard ratios. In the stopping model, the outcome variable is equal to one if the time since the last birth is five years or greater in duration and zero if it is not. Coefficients are presented as odds ratios. Description of covariates may be found in section IV.

[a] indicates the reference category

Source: As for tab. 1.

Paper 2

The emergence of the quality-quantity tradeoff during Stockholm's fertility decline[1]

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Abstract
Using a longitudinal register for Stockholm during its fertility transition, this paper examines how sibling exposure was associated with child quality via social mobility over time and across socioeconomic groups. This is a greatly under-researched topic for this period, which is surprising considering the prominent role of intergenerational transfers in several theories of fertility decline (e.g. Becker and Lewis 1973; Caldwell 1976). This study has found that there was virtually no mobility penalty for children born into larger families during the earliest phases of the fertility decline. It was only for children born in last decade of the nineteenth century that the relationship emerged, and only for individuals with more than two surviving siblings. Furthermore, children from lower socioeconomic classes suffered a greater mobility penalty than those from higher classes. This study suggests that this relationship emerged as the demand for higher education increased due to the Stockholm's continued economic growth.

JEL classifications: D13, J13, N33, N93
Key words: Fertility transition, socioeconomic status, urban, quality-quantity tradeoff, intergenerational mobility, human capital

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[1] Previous versions of this paper have been presented at the 2014 European Population Conference, 2014 Annual Meeting of the Social Science History Association, and the 2015 Annual Meeting of the Population Association of America.

Introduction

The tradeoff between child quality and quantity has a prominent role in both historical and contemporary fertility research. As described by Becker & Lewis (1973) and Becker & Tomes (1976), this mechanism suggests that decreases in a family's number of children should increase parental investment per child, thus raising child quality. As such, it provides a way to understand both individual fertility decisions and children's later-life outcomes. The negative association between family size and children's outcomes has been repeatedly shown in a wide variety of contexts in modern times. Children from larger families have been found to receive smaller human capital investments (Cáceres-Delpiano, 2006; Downey, 1995; Hongbin, Junsen, & Yi, 2008; Rosenzweig & Wolpin, 1980), have worse educational outcomes (Ponczek & Souza, 2012), and receive diminished financial transfers from their parents (Emery, 2013), though the strength of some of these relationships has been questioned (Angrist, Lavy, & Schlosser, 2010; Ferrari &Dalla Zuanna, 2010; Fitzsimons & Malde, 2014).

Despite widespread academic interest in the topic, few studies have taken a historical perspective to identify its existence in the past (e.g., Bras, Kok, & Mandemakers, 2010; Hatton & Martin, 2010; van Bavel, 2006; van Bavel, Moreels, van de Putte, & Matthijs, 2011). In particular, the relationship between family size and children's later-life outcomes during the fertility transition has received surprisingly little attention considering the contentiousness of the debate regarding the transition's causes (see Guinnane, 2011). This paper will contribute to the limited research on the subject by utilizing a longitudinal register from Stockholm, Sweden during its fertility transition. Specifically, it will examine the association of sibling exposure during childhood with one's probability of being upwardly or downwardly mobile.

The study contributes to the existing historical literature in several ways. First, it considers a large, industrializing capital city during its fertility transition using longitudinal micro-data with detailed occupational information. Despite the dataset's impressive scope and depth, it has rarely been used for demographic research. Because there is some strong evidence suggesting that the historical fertility declines of Europe and its offshoots typically began in urban areas (Dribe, 2009; Haines, 1989; Livi-Bacci, 1986; Mosk, 1980; Sharlin, 1986), examining the evolution of the relationship between child quantity and quality in Stockholm may provide insight into the factors contributing to cities' roles as geographic forerunners. Such detailed population data can also yield important findings for modern populations experiencing rapidly changing family size and can inform policy makers on the potential unanticipated effects of fertility decline.

Second, the paper approaches sibship size in a unique way. In addition to defining exposure as the number of siblings surviving by age 15, I further restrict the definition by treating sibling exposure as a continuous measure of shared-person years. This measure has several advantages over the traditional standards. First, it addresses the fact that siblings will impede an individual's access to resources to differing degrees based on the amount of time they share together during childhood, which may vary based on child survivorship, birth spacing, and the timing of siblings leaving the home. Second, it allows for the contribution of exposure from siblings who are born and die before recording one's net siblings at a given age. This point is highly relevant in populations where child mortality is high, as siblings may dilute family resources for several years before dying, but would fail to be represented in a measure of net sibship. Third, because this measure was calculated for the same time span of all individuals at risk (i.e. from birth until age 15), it represents a measure of the intensity of sibling exposure during childhood.

Using these two measures, multinomial logistic regression models are estimated to identify whether or not sibling exposure during childhood was associated with intergenerational mobility and status attainment and how these relationships developed over time. Regardless of how the independent variable was defined, the results indicate that individuals facing greater sibling exposure had a lower probability of upward mobility, while their chances of downward mobility remained unaffected. This association was present in all socioeconomic groups, but its strength was inversely related to one's origin class. Interestingly, sibling exposure was not significantly associated with intergenerational social mobility for cohorts born during the early phases of the fertility transition; the relationship only emerged for cohorts born after the decline had begun. The emergence of this pattern seems to be related to an increasing demand for human capital during the era, evidenced by the finding that the association between sibling exposure and the probability of having a high-status occupation became increasingly negative for later-born cohorts.

Historical Background

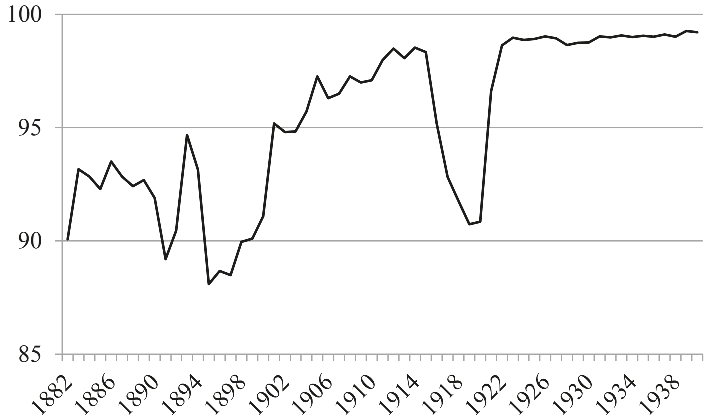
The period under consideration for this study (1878 – 1926) was one of extensive economic and demographic change in Stockholm. During much of the nineteenth century Stockholm's economy was in a state of stagnation, and it appeared that the industrialization process would stall early on. In the first decade of the century, the proportion of workers employed in manufacturing declined by about 25% and some industries, like the silk industry, almost completely vanished from the city (Söderberg, 1987). Such disappointing economic growth persisted until around the middle of the century when real wages began to increase almost continuously (Lundh, Schön, & Svensson, 2004). It was only at the start of this study's period of observation when the purchasing power of workers in Stockholm began to outpace the national average. The growth of wages continued throughout the period, and by 1926 unskilled industrial workers' real wages had increased more than threefold.

The city had secured its place not only as a leader of Swedish industry, but also of trade and administration already by the 1880s. According to official statistics, 16% of workers were employed in the public sector in 1900 while just over half of all individuals worked in the manufacturing sector and about a third were involved with trade (Stockholms Stads Statistiska Kontor, 1905, p. 65). As the country's capital, public employment naturally made up a larger share of the occupational structure than in other industrial cities in Sweden. This, combined with a substantial private administrative workforce involved in trade and commerce, resulted in a fairly large segment of the labor force working in white collar jobs and, in turn, bolstered the general demand for human capital, which could be supplied by the city's relatively progressive educational system and large number of rural-urban migrants.

During this period Swedish education was still in its infancy in much of the country. Despite significant school reforms in 1842 that required all municipalities to have primary schools, attendance varied in scope and in duration in many places until well into the twentieth century (Statistics Sweden, 1974). The reforms required the availability of teachers in all school districts in the country, but in many cases this requirement was merely satisfied through ambulatory schools. For instance, in sparsely populated areas teachers would travel between several municipalities to provide instruction, which was partially responsible for why many rural children only attended school on a part-time basis (Ljungberg & Nilsson, 2009). Furthermore, the duration of compulsory schooling was inconsistent throughout the country until the *Riksdag* passed a mandatory seven-year curriculum in 1936 that was to be in full force by 1948 (Statistics Sweden, 1974). Stockholm was ahead of its time in this sense as most children had already been attending primary school for seven years by the late nineteenth century and on a full-time basis. Tuition was free for all students at this time but parents were responsible for purchasing any school supplies and clothing for their children. It was possible for parents to receive financial support from the government even for these basic goods, but only when parents were physically or mentally incapable of working (Holmlund, 2013). Already in 1882 school attendance was high in the city. Among school-age children (age 7 – 14) about 90% were enrolled in full-time education and attendance fluctuated around this figure until the late 1890s (see figure 1). After that point, the percentage of children enrolled in primary school began to rise and approached complete enrollment of the school-age population by the First World War. Despite Sweden's neutrality in the war, neither the country nor the city was immune to its effects. Between 1915 and 1919 inflation increased tremendously in Stockholm, leading to a nearly fourfold increase in consumer prices, and this had a devastating impact on children's education, presumably due, at least partially, to increases in child labor to offset rising living costs. By the end of the war, school attendance had fallen to around 90%, the same level as nearly four decades prior. As prices fell and real wages arrived at their pre-war trajectory in the early 1920s, school attendance rebounded and once again approached 100% enrollment.

The economic and educational changes in the city were also coupled with a transforming demographic regime. The attractiveness of city life and high wages led to heavy flows of migrants from the countryside and induced rapid population growth. Between 1880 and 1930, the city's population grew from about 176,000 to over half a million. At the same time and in spite of wretched sanitary conditions for much of the population, mortality began its descent. Life expectancy at birth for males increased from 26 years in 1871-1880 to 57 years in 1921-1930 and the rise was almost entirely due to dramatic improvements in child survival. In the 1870s, the probability of dying before age five (${}_5q_0$) hovered around 0.4 in Stockholm compared to about 0.2 in Sweden as a whole. Childhood mortality improved rapidly throughout the following decades and eventually would be on par with national levels by the 1920s when ${}_5q_0$ was about 0.08. But despite improvements in survivorship, there was tremendous variation across socioeconomic groups. At the start of observation the children of the unskilled working classes were two to three times as likely to die in the first years of life compared to those of the upper classes (Burström et al., 2005; see Paper 3). Although infant and child mortality declined for all socioeconomic groups throughout the demographic transition, the relative differences between them hardly changed.

Figure 1. Percentage of school-age children (age 7 – 14) enrolled in primary education in Stockholm 1882 – 1940.

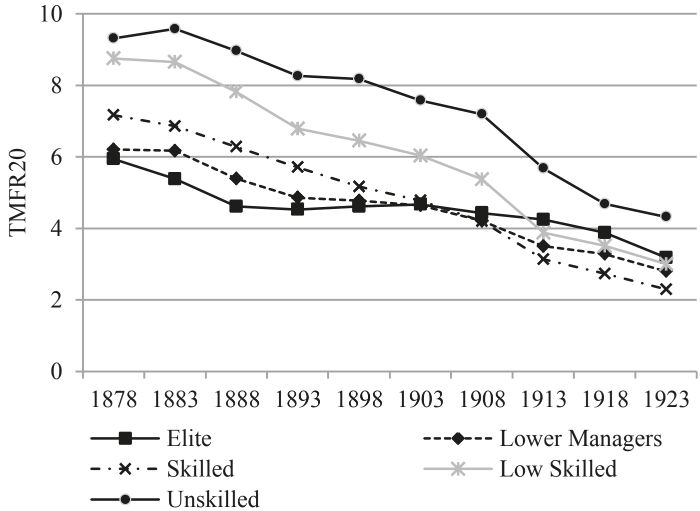


Notes: These figures refer to the percentage of all children, which includes those unable to attend school due to health or other reasons.

Source: For the years 1882 – 1899, the data come from Bidrag till Sveriges Officiela Statistik, P.)Undervisningsväsendet. For the years 1900 – 1940, the data were taken from Statistisk Årsbok för Stockholms Stad for the respective years.

As migrants continued to flood the city and mortality started to decline, fertility also began to decrease. Stockholm's fertility transition began in earnest during the early 1880s. Total marital fertility from age 20 to 49 (TMFR20) was near eight births per woman in 1878 and fell to just over three births per woman by 1925. This was largely a result of increased 'stopping' behavior at lower parities. For cohorts born between 1858 and 1886, for example, the mean age at last birth declined from almost 35 years old to 30 years old and the largest decreases in parity progression ratios occurred for the transition from two to three children and three to four children. The decline of fertility in Stockholm took on a strikingly clear socioeconomic pattern in which upper class women had lower levels of fertility already from the outset of the transition and also were the first to begin limiting their fertility compared to the working classes (see figure 2) (Molitoris & Dribe, forthcoming). It was only thereafter that the working classes would lower their fertility and begin to converge with the elite groups. These trends were similar to the socioeconomic distribution of infant and child mortality, which also varied inversely with class. As the transition proceeded, the cross-sectional variation of both fertility and child mortality between classes diminished considerably.

Figure 2. TMFR20 by socioeconomic class, 1878 – 1926.



Notes: TMFR20 refers to the hypothetical number of children a married woman would have if she were to be exposed to the same age specific rates throughout her childbearing years. Age-specific rates calculated per 1,000 woman-years.

Source: See Data section.

The economic and demographic changes of the late-nineteenth and early-twentieth centuries certainly had momentous influence on living standards, but the connections between them are less clear. One such connection that is critical to understanding the fertility decline is whether or not small families were economically beneficial for children. This paper attempts to shed light on the relationship between parents' fertility and children's later-life economic performance by analyzing how individuals' socioeconomic mobility relative to their fathers was associated with sibling exposure during a period when fertility varied widely in the cross-section and over time.

Theory and Previous Research

Becker and Lewis (1973) formulated a theoretical model to explain how changes in the economy, specifically prices or income, should impact couples' demand for children. Couples are viewed as agents who strive to maximize a utility function by combining a mixture of child quantity, child quality, and the consumption of market goods. In their framework, a familial budget constraint exists, such that:

$$I = n\pi_n + nq\pi + q\pi_q + yp_y$$

where I is full income, n is the number of children, q is the level of child quality, π is the price of the interaction of n and q, y is the rate of consumption of other commodities, and p_y is the marginal cost of consuming other commodities.

Although their model is specifically interested in explaining how parents make fertility decisions, it also has implications for children's outcomes. Among these implications is that children born into larger families, *ceteris paribus*, should be of a lower quality on average (i.e. have lower education or health). Galor and Moav (2002) argue that the tradeoff between quantity and quality of children is a fundamental natural relationship between fertility and resources. Galor (2011) expanded on this and argued that parents' optimal number of children should decline if, among other things, the technological environment changes more rapidly. This is particularly the case if technologies emerge that are skill-biased rather than skill-saving, as they will raise the returns to human capital and push parents towards investing more in their children's education (Galor & Weil, 2000). Together, this suggests that during times when the demand for human capital is increasing, the relationship between family size and children's outcomes should grow stronger. That is, disparities in the outcomes of children born in smaller versus larger families should widen. The strength of this tradeoff will be mediated by parental resources, such as income, education, social capital, and inherent ability. Better educated or higher skilled parents should have a comparative advantage in raising higher quality children as education incurs a "resource cost", while the basic cost of child quantity is a "time cost" (Moav, 2005; de la Croix & Doepke, 2009). In other words, parents with greater resources should be able to offset some of the negative influences of family size on their children's outcomes.

In the last two decades researchers have explored the quality-quantity tradeoff in detail using data from a host of modern populations at different phases in their economic development. Employing a variety of control strategies, several studies have identified a tradeoff between family size and children's educational outcomes (Cáceres-Delpiano, 2006; Hongbin et al., 2008; Maralani, 2008; Ponczek & Souza, 2012; Rosenzweig & Wolpin, 1980). Despite these findings, however, others have found a weak to non-existent relationship between the variables (Angrist et al., 2010; Anh, Knodel, Lam, & Friedman, 1998; Black, Devereux, & Salvanes, 2005; Blake, 1981; Downey, 1995; Ferrari & Dalla Zuanna, 2010; Fitzsimons & Malde, 2014). Others have argued that even if there is a relationship between family size and children's outcomes, it is highly dependent on levels of economic development and local conditions, with the tradeoff being stronger in times and places with worse educational infrastructure and lower demand for human capital (Hongbin et al., 2008; Maralani, 2008; Ponczek & Souza, 2012). Thus, there is little agreement about whether or not this relationship exists in modern populations.

Our knowledge of the relationship between family size and children's outcomes in the past is even more nebulous than for modern times, being limited to only a handful of studies. Few have examined this relationship during the fertility transition, and even fewer have done so for the pre-transitional period. One study of 26 English parishes between the sixteenth and eighteenth centuries found that men born into socioeconomic groups with higher fertility tended to be downwardly mobile (Boberg-Fazlic, Sharp, & Weisdorf, 2011). For pre-transitional Prussia it has been shown that counties with higher child-woman ratios tended to have substantially lower primary school enrollment, and that the level of a county's education in 1849 predicts the rate of fertility decline at the end of the nineteenth century (Becker, Cinnirella, & Woessmann, 2010).

In recent years, several researchers have examined the relationship between children's outcomes and family size using individual-level data during the fertility decline. Two studies of Belgian cities during their respective fertility transitions indicate an association between family size and socioeconomic mobility, yet with slightly different implications. For the city of Leuven, there is evidence that children with more siblings tended to have both reduced odds of upward mobility and increased odds of downward mobility and this association did not vary based on an individual's socioeconomic background (van Bavel, 2006). In the larger city of Antwerp, an association was also found, but smaller families were only effective in reducing one's odds of downward mobility and shared no association with upward mobility (van Bavel et al., 2011). In contrast to Leuven, however, children from higher socioeconomic groups tended to be more greatly impacted by family size than those from working-class families. Research on the Dutch fertility transition has revealed considerable heterogeneity in this relationship, as has also been shown in modern populations (Bras et al., 2010). Depending on local characteristics, such as being from a rural area or originating from an area where tight-knit kin networks proliferate, sibship size could even *increase* one's odds of being upwardly mobile. They also document that there was a fundamental shift over time, in which the negative relationship with sibship size and social status emerged during economic development. Children's exposure to siblings has not only been found to be associated with intergenerational socioeconomic mobility, but also with other indicators of child quality such as heights and mortality. A study of British children's heights between 1886 and 1938 found a negative association between height and the number of siblings as well as a positive relationship between household income and height, and these associations strengthened after the turn of the twentieth century (Hatton & Martin, 2010). The negative association between fertility and heights has also been documented during the early years of the French fertility decline (Weir, 1993).

This study contributes to the historical body of research by analyzing the association between sibling exposure and intergenerational socioeconomic mobility during Stockholm's fertility transition. The advantage of using this outcome is that occupational information is readily available in many historical datasets and serves as a good proxy for inferring parental investments in their children, as children's later-life occupational outcomes should, on average, be a reasonable reflection of their education and health during childhood. As such, this paper aims to test several hypotheses.

The primary hypothesis is concerned with the evolution of the quality-quantity tradeoff during Stockholm's fertility decline. If parents do indeed substitute child quality for child quantity, the relationship between sibling exposure and socioeconomic mobility should have been present even before the fertility transition, but should have strengthened for cohorts born at the start of the decline. In particular, the relationship between the two should have been the strongest for the cohorts born after 1890, for which primary school enrollment approached 100% and secondary school enrollment began to rise, signaling a growing demand for human capital (Statistics Sweden, 1977). This would be in line with the theoretical expectation that if the returns to human capital are greater parents will invest more heavily in child quality versus child quantity, thus penalizing children from larger families (Galor, 2011). As the demand for children's human capital increased and pressure mounted for parents to finance more years of their children's education, individuals from larger families should have had decreased odds of upward mobility and increased odds of downward mobility.

The second hypothesis is that the strength of this relationship should vary inversely with the socioeconomic status of parents. If per capita investments in education are the mechanism through which differential mobility outcomes materialize, one would expect that educational investments of wealthier parents should be less sensitive to larger family sizes. Children born into the working classes should have a larger mobility penalty as sibling exposure increases compared to the middle class. This difference should stem from differences in not only parental income, but also assets and social capital. Even if wealthier parents with larger families do not invest as heavily in each of their children's human capital as those with smaller families, they should have been able to at least partially offset downward mobility through bequeaths and their social networks. Therefore, working-class children's mobility should be disproportionately negatively associated with sibling exposure, while middle-class children should show no negative association between the two.

Data

The data used for this study come from the Roteman Database, a population register kept for Stockholm, Sweden between 1878 and 1926. The Roteman System was established in order to improve the quality of record keeping for the municipality. As migration increasingly expanded Stockholm's borders and density, traditional record keepers (i.e. parish priests) experienced difficulty in recording all vital events and movements within their respective parishes. This led to the establishment of the Roteman System by the city government on January 1, 1878 (Geschwind & Fogelvik, 2000).

The longitudinal register contains all individuals ever residing in the city during this period. The data used for this study is an extract from the larger database containing all women ever present in the city and any person linked to them (i.e. children, husbands/partners, lodgers, employees). This amounts to 3.7 million observations of about 970,000 unique individuals over the 48 year period. It has detailed information on migration, occupation, fertility and mortality. Each individual's records were updated upon births, deaths and movements within or outside of the city and also annually at the time of census registration, allowing for the observation of individual variation in a host of features over time. The structure of the data is spell-based with information explaining how each spell begins and ends. For instance, it is known if a spell began with a birth and ended with out-migration.

A great advantage of these data is that they offer detailed, time-varying information on individuals' occupations. With this information one can test various hypotheses that demand a socioeconomic dimension. Occupations were coded using the Historical International Standard Classification of Occupations (HISCO) (van Leeuwen, Maas, & Miles, 2002). Using the HISCO information, a socioeconomic class variable was created using HISCLASS, which generates a 12-category classification scheme based on required skill level, degree of supervision, manual or non-manual character of work, and whether it is an urban or rural position (van Leeuwen & Maas, 2011). These 12 categories were then aggregated up to five categories plus a category with no stated occupation to avoid problems of small numbers.[2] Nevertheless, the new categorization maintains the spirit of the original classification.

[2] The socioeconomic groups were classified as follows (HISCLASS codes in parentheses): Elite (1, 2), Lower Managers (3, 4, 5), Skilled Workers (6, 7, 8), Lower Skilled Workers (9, 10), Unskilled Workers (11, 12).

Sample Selection

The requirements of being included in the final analysis sample were fairly restrictive, and this naturally came at the cost of reducing the sample size. The first criterion for inclusion was being born in Stockholm. This was done to ensure that exposure to siblings could be observed completely from birth. If a mother had any children who were born and died prior to those born in Stockholm, they would contribute nothing to sibling exposure. If this criterion was not included, there would be no way of being sure of the sibling exposure experienced in the first years of life.

Second, the children used in the analysis are male. This decision is one based on interpretability of results rather than data availability. It is possible to follow women over time as well, but most left the formal labor market upon marriage. Those who could be followed and observed as working would therefore be a highly unrepresentative group. Alternatively, if one were to assign a husband's occupation to women to estimate their socioeconomic status, the mechanisms linking family size and this outcome become less clear. To argue that sibling exposure should be associated with women's marriage partners would require not only that those from smaller families tended to be better educated, but also that they would be successful in marrying a man with higher education as well. This connection is further complicated by the fact that, during the period of observation, there was very little heterogeneity in terms of education among women as an extremely low number of women attended secondary school at this time. In 1900, for example, only 1% of girls extended their schooling beyond the compulsory seven years compared to 11% of boys (Stockholms Stads Statistiska Kontor, 1905). For these reasons, this study focuses exclusively on male children.

Third, individuals must be followed up until they were *at least* 30 years old. This was chosen to take into account the fact that age is correlated with occupational mobility. It could be argued that observing someone until age 30 does not fully resolve the problem, but this is a compromise between introducing more selection bias and correctly identifying occupational mobility. Restricting the sample even more greatly reduces the number of individuals who can be observed.

Fourth, the children must come from a home with a father present. Without this information, it would be impossible to have any idea of intergenerational mobility, because, as already mentioned, so few women had recorded occupations beyond their mid-20s. Those that did were almost exclusively working in low skilled positions, such as maids and seamstresses. This requirement does not, however, preclude illegitimate children from being included in the analysis. The data indicate whether a child was born out of wedlock and also identifies whether an illegitimate child belonged to the father's household or was born outside of the household. Thus there is no requirement that the parents must have been married.

Fifth, both the father and son must have had non-missing occupational information. Using the aforementioned five-class scheme, each individual was assigned the maximum socioeconomic class that was attained by their father before they were age 15. This forms their childhood class variable. Sons' adult class was defined as the maximum socioeconomic class they achieved at or above age 30. The transition between the two or lack thereof represents the outcome of interest for this study. Table 1 reveals a simple cross-tabulation of father's and son's classes. It is clear that children born into the elite and lower managers groups tended to replicate their father's class more than children born into the lower classes. Furthermore, about a third of those born to the lower managers group experienced downward mobility, though these moves were mostly into the adjacent skilled workers category. On the other hand, children born into the lower skilled and unskilled groups tended to be upwardly mobile despite the fact that these were classes with very high levels of fertility during this time, as could be seen in figure 2.

The above restrictions amount to a total of 7,200 males who can be observed between birth and age 30. Of the 42,460 male births observed between 1878 and 1896, this makes up about 17% of all those born in the city. Of course, not all of the lack of follow-up is due to selective out-migration. Some of it is simply due to mortality. After adjusting for the number of observed deaths of these cohorts (i.e. those dying in Stockholm prior to age 30) the percentage of survivors that can be followed increases to about 25%. It is unclear how many of the out-migrants died before age 30, but the percentage of the cohort survivors that can be followed will nevertheless be even higher.

Table 1. Comparison of fathers' and sons' socioeconomic status.

Father's Class		Son's Class: Elite	Lower Managers	Skilled Workers	Lower Skilled	Unskilled	Number of Fathers
Father's Class	Elite	55.7	21.4	19.5	2.5	1.0	406
	Lower Managers	18.9	48.0	18.5	7.4	7.2	1734
	Skilled Workers	8.0	29.0	35.7	14.5	12.9	2193
	Lower Skilled	4.5	26.6	31.1	22.9	14.9	1593
	Unskilled	2.3	26.4	29.3	20.2	21.8	1323
	Number of Sons	830	2329	2067	1087	936	

Notes: All rows sum to 100%. Shaded boxes in the diagonal indicate the percentage of sons who replicated their father's class. Figures refer to all males observed from birth until at least age 30 in Stockholm.

Source: See Data and Sample Selection sections.

When imposing so many restrictions on the sample, there is obviously a concern about introducing selection bias into the analysis. The primary questions that come to mind are: who are the individuals that remain in the same place for 30 years or more? And how do they differ from those that leave? To address this, a logistic regression was used to estimate one's probability of remaining under observation for the analysis. The dependent variable was whether a male met all of the above criteria for inclusion and the dependent variables were characteristics assigned from birth. The results of the analysis are shown in table 2.

Table 2.Predicted probabilities of being included in analysis sample by characteristics at birth.

Variable	Predicted Probability	Variable	Predicted Probability
Mother's Age at Birth:		Father's Socioeconomic Group:	
15 to 19	0.275	Elite	0.293
20 to 24	0.261	Lower Managers	0.295
25 to 29	0.256	Skilled Workers	0.250
30 to 34	0.256	Lower Skilled	0.253
35 to 39	0.258	Unskilled	0.229
40 to 44	0.261	Legitimacy:	
45 to 49	0.269	Born within Wedlock	0.253
Birth District:		Born outside Wedlock	0.347
Gamla Stan	0.296	Birth order:	
Norrmalm	0.251	1	0.266
Kungsholmen	0.233	2	0.259
Östermalm	0.234	3	0.257
Södermalm-East	0.271	4	0.255
Södermalm-West	0.283	5	0.254
Mother's Birth Place:		6	0.251
Stockholm City	0.261	7	0.248
Stockholm County	0.085	8	0.246
Other Sweden	0.075	9	0.246
Outside Sweden	0.119	10+	0.246
Undefined	0.220		

Notes: The above predicted probabilities were taken from a logistic regression, where the dependent variable was equal to one if a male could be observed from birth until age 30. Neither females nor individuals with missing socioeconomic information were included in this model.

Source: See Data and Sample Selection sections.

There were no large differences between classes, though the elite and lower managers groups were slightly more likely to be included in the final sample. The class differences in inclusion probabilities appear to have been primarily driven by differential childhood mortality. For the elite group, about 15% of those not included in the sample had died before age 30, whereas for the unskilled groups this figure was 38%.[3] For those individuals surviving until at least age 30, there were no significant differences in the proportion remaining based on class. For all socioeconomic groups nearly 30% of survivors remained in Stockholm while the remainder migrated out of the city.

Method

To analyze how sibling exposure was associated with socioeconomic mobility, multinomial logistic regressions are employed. The categorical dependent variable could take on three values representing upward mobility, non-mobility and downward mobility with non-mobility serving as the reference outcome. The main independent variable of interest is the number of living siblings within the household at age 15. This cutoff point was chosen because significant proportions of children left home already by the mid- to late-teens and, presumably, became net producers rather than net consumers within the household thereafter, thus becoming less dependent on intergenerational transfers (see Dribe & Stanfors, 2005; Guinnane, 1992; Pooley & Turnbull, 1997). The model controls for one's birth order, illegitimacy status, cohort, mother's age at birth, age at recording of maximum socioeconomic class and father's maximum achieved socioeconomic class. Birth cohorts were clustered into three categories to ensure each had large enough numbers for analysis and also to reflect the nature of fertility in those cohorts with respect to the fertility transition. The categories were: 1878-1883 (late pre-transition), 1884-1890 (early transition), and 1891-1896 (accelerating transition). Additionally, in order to control for changes in the occupational structure over time, a control variable is included which measures the relative size of one's origin class in the year in which an individual reaches their maximum occupational status. The descriptive

[3] The corresponding shares of children not observed until age 30 due to mortality for the remaining groups were: 27% for lower managers, 32% for skilled workers, and 32% for lower skilled workers.

statistics may be found in table 3. To account for correlation between brothers, standard errors were clustered at the family level. Because not all sons could be upwardly or downwardly mobile due to their fathers' coming from the highest and lowest socioeconomic groups, the models only consider the sons originating in the middle three groups. In order to test the aforementioned hypotheses, interactions between origin class and sibling exposure, as well as birth cohort and sibling exposure are included in an extended version of the model. These models are then used to calculate predicted probabilities to evaluate the strength of the association between the variables. Later in the analysis, the same specifications will be used to study how sibling exposure was associated with one's status attainment.

In addition to the above models, this study will also seek to refine sibship size to more precisely identify the intensity of sibling exposure. Although one's number of siblings is certainly a discrete variable, exposure to those siblings is not. For instance, an individual with two siblings at age 15 could, on the one hand, share little of his childhood with them if he had been born to a young mother. On the other extreme, he could have been born as a triplet and share the entirety of his childhood with these siblings. Children's expected endowments are often treated as the quotient of parental resources divided by an unweighted number of siblings. But the above example shows that this may be misleading and that there is a need to somehow adjust for both the age distribution of siblings as well as child mortality. In a low mortality population with fairly constant birth intervals, it may well be sufficient to simply weight each sibling's exposure by their age to account for disproportionate exposure to siblings (see Öberg, 2015), though this still may underestimate exposure depending on, for example, the normative age of leaving the household.

Table 3. Descriptive statistics of analysis sample.

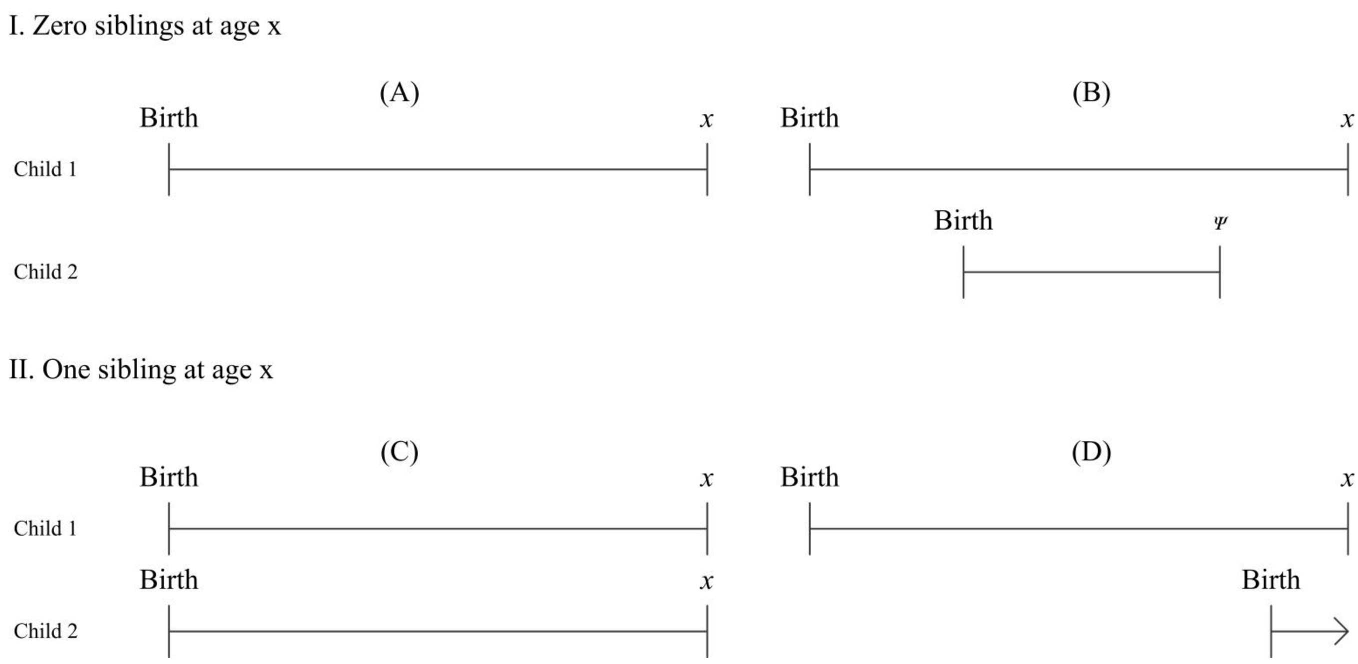
	N	%	Min	Max	Mean	SD
Mobility						
Upward	2120	38.7				
None	1965	35.8				
Downward	1398	25.5				
Cohort						
1878-1883	1693	30.9				
1884-1890	2450	44.7				
1891-1896	1340	24.4				
Born out of Wedlock	351	6.4				
Father's Class						
Lower Managers	1725	31.5				
Skilled Workers	2177	39.7				
Lower Skilled	1581	28.8				
Net Siblings at age 15	5483		0	13	3.1	2.2
Shared Person-Years	5483		0	136.7	30.8	20.5
Birth Order	5483		1	13	3.2	2.2
Mother's Age at Birth	5483		17	49	30.4	5.9
Year of Status Attainment	5483		1896	1926	1916	6.5
Proportion of Father's Class in Year of Maximum Status Attainment	5483		17.3	30.2	24.0	4.3

Source: See Data section.

Figure 3 demonstrates how this measure better approximates exposure. First, we may consider a child who, upon reaching a given age *x,* was recorded as having zero siblings. In family A, the child truly had no other siblings born before that age. In family B, however, the child had a sibling who was born and died prior to the recording of sibship size. Clearly, simply summing the number of siblings at a given age underestimates the true exposure this individual experienced. By the same token, if we were to instead define sibling exposure as the gross number of siblings born, we would be overestimating the exposure contributed by that sibling. The same could be said for issues of birth spacing. In family C, two siblings are born as twins and therefore contribute full exposure throughout childhood. These individuals would be recorded as having one sibling at age *x.* But family D shows two children who were spaced very far apart. The standard discrete measure would still assign one sibling to child 1, despite the fact that he was only marginally exposed during childhood. And, assuming family D has no more children, child 2 would be recorded as having zero siblings at age *x,* although he was partially exposed to an older sibling during infancy. Using person-years as a measure of sibling exposure therefore ensures all of this information is not discarded.

With these considerations in mind and to complement the standard discrete measure, I have defined sibling exposure as a continuous measure, the number of person-years an individual shared with his siblings (both male and female) until age 15. This definition accounts for differential exposure contributed by siblings due to child mortality as well as birth spacing, two fundamental demographic aspects that were changing drastically during the period, and better captures the amount of exposure contributing to the dilution of parental resources.

Figure 3. Stylized representation of variable sibling exposure with respect to observed living siblings at age x.



Results

During this period, intergenerational mobility appears to have been shifting towards greater upward mobility and less downward mobility, though the percentage of individuals replicating their fathers' class appears to have remained virtually unchanged (table 4). For the earliest born cohort (1878 – 1883), non-mobility was the most common outcome, followed closely by upward mobility. For the cohort born between 1891-1896 upward mobility had become increasingly common and downward mobility much less so. In this way Stockholm differs from rural Sweden, where downward mobility was becoming the norm as the nineteenth century progressed (Dribe, Helgertz & van de Putte, 2015). This difference is unsurprising. In rural areas, improvements in agricultural technology allowed for a concentration of land and physical capital among wealthy rural landholders, while industrial technological innovations likely increased the demand for human capital in urban areas (Dribe & Svensson, 2008).

Table 5 reveals that total intergenerational mobility was fairly constant across cohorts for individuals born into any class other than the elite group. For that group, total mobility fell drastically, revealing a trend in which fathers became more successful at transferring their own status to their sons over time. In the latest-born cohort, nearly 60% of their sons retained their origin class, while among the lower classes only slightly more than 20% would replicate the status of their father. The stagnation of total mobility reported in tables 4 and 5 has also been reported for Sundsvall, an industrial city in northern Sweden. There total intergenerational mobility increased during industrialization until about the end of the nineteenth century, when the trend stalled (Maas & Van Leeuwen, 2002).

When comparing levels of sibling exposure across types of mobility, it becomes clear that mean sibling exposure tended to be lower for upwardly mobile sons (table 6). Whether measured continuously or discretely this finding remains consistent. Furthermore, differences in mean exposure appear to have grown for later-born cohorts, while there was less variation in exposure between outcomes for the earlier-born cohorts.

Table 4. Distribution of intergenerational social mobility by birth cohort.

	Upward	None	Downward
1878-1883	35.4	36.7	27.9
1884-1890	39.6	35.6	24.9
1891-1896	41.9	34.8	23.3

Source: See Data section.

Table 5. Total mobility across origin class by birth cohort.

	Elite	Lower Managers	Skilled	Low Skilled	Unskilled
1878-1883	51.7	52.5	65.6	74.9	78.4
1884-1890	39.4	52.9	63.2	78.5	77.4
1891-1896	41.1	48.8	64.6	77.2	79.2

Notes: Figures refer to the percentage of individuals being either upwardly or downwardly mobile relative to their father's class within each birth cohort.

Source: See Data section.

Table 6. Mean sibling exposure for outcomes of intergenerational mobility by birth cohort.

	Mean Surviving Siblings at age 15			Mean Shared Person-Years until age 15		
	Upward	None	Downward	Upward	None	Downward
1878-1883	4.3	4.3	4.4	29.5	31.1	30.9
1884-1890	4.3	4.6	4.6	30.1	32.2	31.5
1891-1896	4.3	4.7	4.8	27.4	31.9	32.3

Source: See Data section.

To explore this relationship in more detail, multinomial logistic regression models are used. The results of the models (table 7) indicate a statistically significant negative association between sibling exposure and upward socioeconomic mobility when holding all other variables constant. Regardless of whether exposure is defined as a discrete or continuous measure, the association holds and is significant at the 1% level. The size of the coefficients reported for the continuous measure of sibling exposure are smaller than those for the discrete measure, but this is simply due to the scale of the variable. An increase of one person-year is a smaller change in sibling exposure than an increase of one sibling. When using the discrete measure, exposure was also associated with a decrease in the relative risk of downward socioeconomic mobility and this was significant at the 10% level. Using the more precise measure of shared person-years, however, did not reproduce this result.

An interaction term of one's origin class and its relative size when an individual reached his maximum class was included. This allows for interpreting the coefficient of origin class as it's the association when the relative sizes of all classes are equal. The origin class coefficients reveal that there was a substantial difference in one's mobility that was purely due to the socioeconomic stratum in which an individual was born. The results indicate that children originating in the lower skilled group had substantially higher odds of being upwardly mobile and lower odds of being downwardly mobile when compared to the children of lower managers. These coefficients were both statistically significant at the 5% level. The odds of mobility in any direction for children of the skilled, on the other hand, were not statistically different from the reference group.

There was also a strong negative effect of birth cohort on upward mobility. Because the data coverage ends in 1926, it is possible that this association is purely being driven by the fact that older cohorts can be observed longer and that individuals typically reach their maximum occupation later than their early thirties. To test this, I restricted the sample to only individuals observed until age 30 (results not shown). The results remained robust to this specification.

Table 7. Multinomial logistic regression of sibling exposure on intergenerational social mobility.

	Exposure= Net Siblings at age 15				Exposure= Cumulative Person-Years by age 15			
	Upward Mobility		Downward Mobility		Upward Mobility		Downward Mobility	
	RRR	p-value	RRR	p-value	RRR	p-value	RRR	p-value
Sibling Exposure	0.93	0.001	0.95	0.053	0.99	0.001	1.00	0.147
Birth Order	1.00	0.852	1.07	0.016	0.98	0.339	1.04	0.046
Mother's Age at Birth	1.01	0.106	1.00	0.588	1.01	0.129	1.00	0.533
Born Out of Wedlock	0.68	0.005	1.20	0.224	0.66	0.003	1.18	0.253
Year of Class Attainment	1.05	0.000	0.98	0.014	1.05	0.000	0.98	0.013
Size of Father's Class during Adulthood	1.05	0.351	1.05	0.423	1.05	0.359	1.05	0.423
Father's Class								
Lower Managers (ref.)	1.00	-	1.00	-	1.00	-	1.00	-
Skilled Workers	1.59	0.629	0.65	0.623	1.65	0.602	0.65	0.626
Lower Skilled	4.61	0.043	0.13	0.034	4.66	0.042	0.13	0.034
…. x Size of Father's Class								
Skilled	1.06	0.805	1.05	0.811	1.05	0.827	1.05	0.816
Lower Skilled	0.86	0.374	0.67	0.044	0.87	0.383	0.67	0.044

(continued on next page)

Table 7 (continued)

	Exposure= Net Siblings at age 15				Exposure= Cumulative Person-Years by age 15			
	Upward Mobility		Downward Mobility		Upward Mobility		Downward Mobility	
	RRR	p-value	RRR	p-value	RRR	p-value	RRR	p-value
Cohort								
1878-1883 (ref.)	1.00	-	1.00	-	1.00	-	1.00	-
1884-1890	0.86	0.083	1.01	0.869	0.86	0.081	1.02	0.864
1891-1896	0.65	0.000	1.02	0.843	0.65	0.000	1.02	0.854
Constant	0.40	0.000	0.59	0.021	0.43	0.000	0.59	0.024
Observations	5483				5483			
Chi2	709.5				706.8			
McFadden's R2	0.076				0.074			

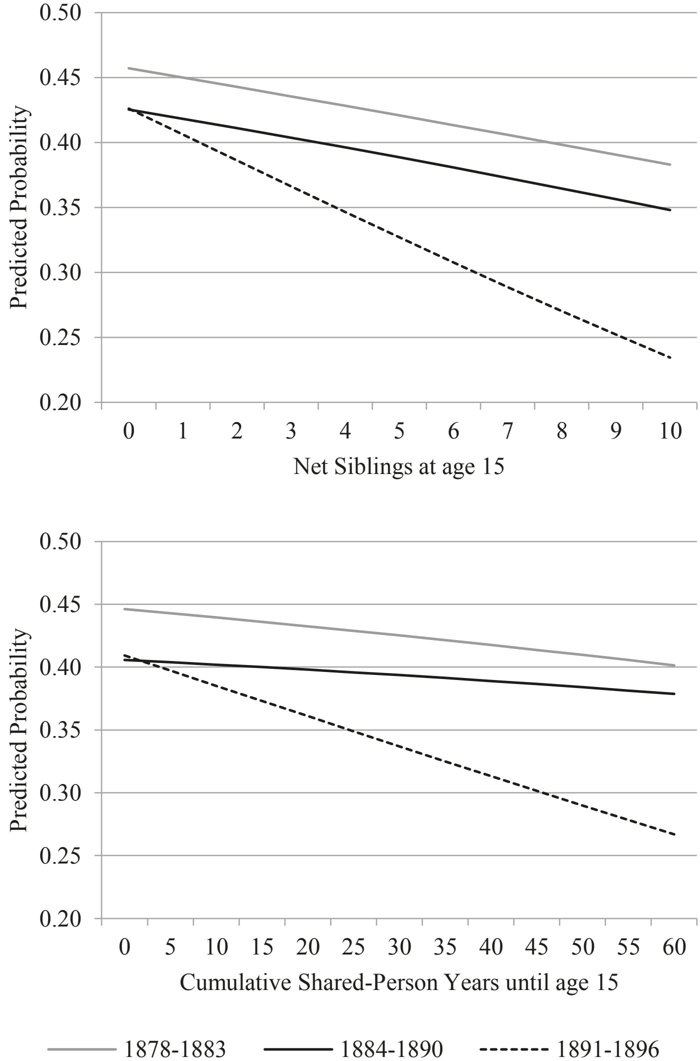
Notes: Coefficients reported as relative risk ratios (RRR). Standard errors were clustered by family. Size of father's class was centered around 20 while the year of class attainment was centered around the mean.

Source: See Data and Method sections.

In order to test how the association between sibling exposure evolved over time and across groups, a further model was run which included two interaction terms between exposure and origin class as well as between exposure and birth cohort. As in the previous model, no statistically significant association between downward mobility and sibling exposure could be detected. This result held both over time and across socioeconomic origins. From these models, predicted probabilities of upward mobility were generated at increasing levels of sibling exposure (figure 4). Here, a clear trend emerges in which children born earlier faced little to no upward mobility penalty with regard to sibling exposure. In the earlier two cohorts, one's probability of upward mobility was primarily due to factors other than sibling exposure during childhood. For instance, origin class was important for all birth cohorts in determining one's chances for mobility, but it was not until the cohorts born at the end of the nineteenth century that heterogeneity associated with sibling exposure emerged. This finding is particularly interesting because it suggests the emergence of a tradeoff between child quantity and quality *after* fertility had begun its decline and indicates that this relationship may not have been a constant mechanism affecting parents' fertility choices in the past, as argued by Galor and Moav (2002).

Figure 5 presents contrasts of the predicted probabilities to determine if there were statistically significant differences in the probability of upward mobility between cohorts. Comparing the cohorts born in 1878-1883 with the 1884-1890 cohorts, there was no statistically significant difference between them at any level of sibling exposure. For those born in 1891-1896, on the other hand, there emerged a clear difference compared to previous cohorts. Children with more than two surviving siblings showed lower probabilities of being upwardly mobile, while the probabilities of those with two or fewer were not statistically different from previous cohorts. These results may indicate the emergence of a new range of optimal family sizes after fertility began its descent. One plausible explanation of why children born into larger families came to face a mobility penalty is that the demand for human capital increased for the latest-born cohorts, allowing parents with fewer children to invest more in each one's education.

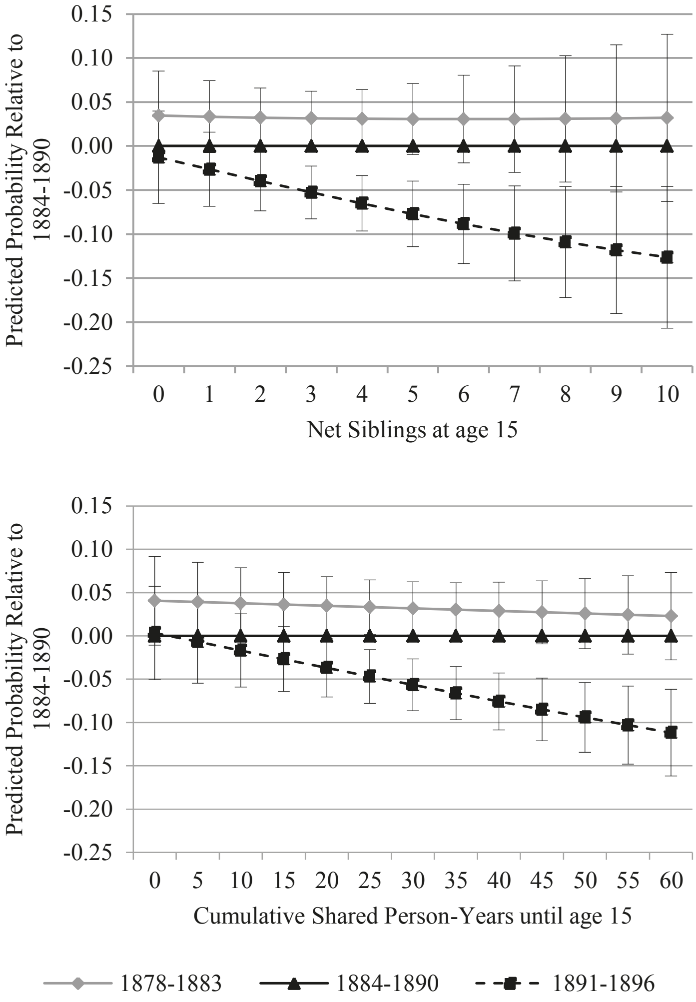
Figure 4. Predicted probability of upward mobility by sibling exposure across birth cohorts.



Notes: Probabilities were predicted at the means of covariates.

Source: See Results section.

Figure 5. Contrasts of predicted probabilities of upward mobility by sibling exposure across birth cohorts.



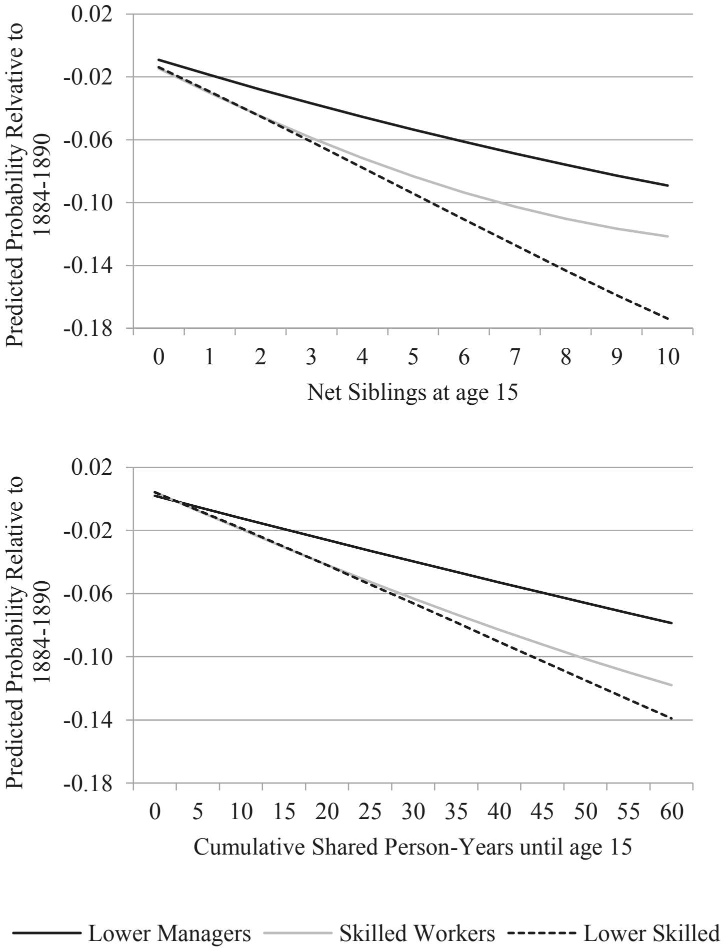
Notes: Contrasts refer to the difference in predicted probability of upward mobility at values of sibling exposure between cohorts and the reference group (i.e. 1884-1890). 95% confidence intervals presented.

Source: See Results section.

The interaction of socioeconomic status and sibling exposure across cohorts supports this interpretation. If larger families made it more difficult for parents to finance their children's education thereby diminishing their odds of upward mobility, we would expect that children originating from wealthier socioeconomic groups would be less impacted by greater sibling exposure. Figure 6 shows how the probabilities of upward mobility for children originating from each class differed across cohorts at different levels of exposure. All classes exhibited similar patterns in terms of the shift across cohorts, with the latest born cohort being most sensitive to sibling exposure. Yet the change in this association was most pronounced for individuals originating in poorer classes. Children born into the lower skilled workers group had a decrease in the probability of upward mobility that was about twice as large as children born into the lower managers group. This finding offers some support to the hypothesis that wealthier families should have been able to at least dampen the effects of resource dilution through other means, such as through intergenerational asset transfers or class-specific social capital.

To further assess whether it was a growing demand for human capital that was responsible for this shift, I will now examine the relationship between sibling exposure and status attainment. The above analysis examined how sibling exposure was associated with intergenerational mobility relative to one's parents. I will now instead look at how sibling exposure influenced one's probability of ending up in specific socioeconomic groups. If the relationships described above are due to an increasing demand for human capital, we would expect that sibling exposure should have become increasingly negatively associated with attaining statuses requiring high education (i.e. Elite and Lower Managers) and should have had no association with ending up in statuses requiring no education (i.e. Unskilled).

Figure 6. Contrasts of predicted probabilities of upward mobility for cohorts born between 1884-1890 and 1891-1896 by level of sibling exposure across origin classes.



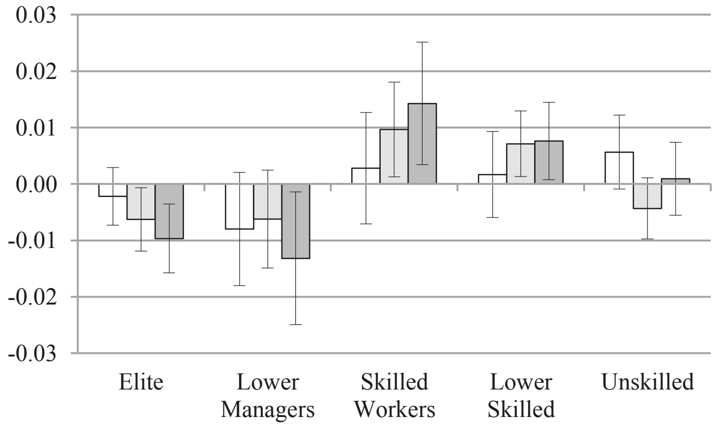
Notes: Each line should be interpreted as a comparison within origin class and between birth cohorts. Confidence intervals omitted for legibility. All groups showed a statistically significant difference from 1884-1890 at 3 net siblings and 20 shared person-years.

Source: See Results section.

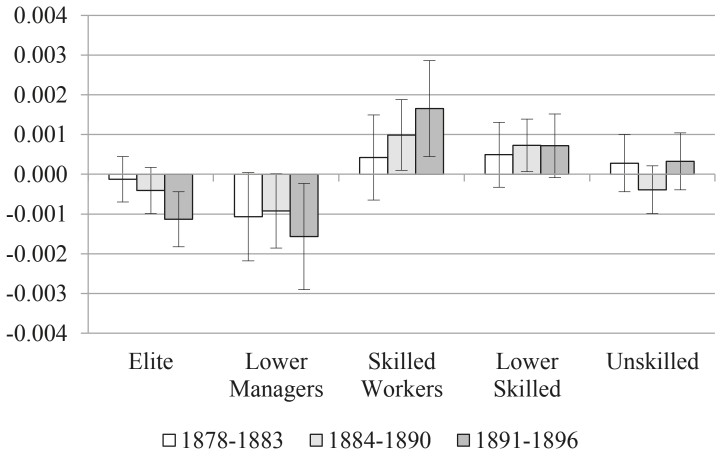
Multinomial logistic regression models were estimated using the same specifications as above to generate predicted probabilities of status attainment. The only difference in these models was that the outcome variable was the maximum class of the son observed at or after age 30 (full regression results not shown). Figure 7 shows the absolute change in the probability of attaining a given socioeconomic status with respect to a one unit change in sibling exposure. The results are consistent with the previous analyses and provide further support to the idea that the quality-quantity tradeoff emerged as a result of a growing demand for human capital. Greater exposure to siblings during childhood became increasingly negatively associated with ending up in either the elite or lower managers group across cohorts. For those born before 1891, there was no statistically significant relationship between attaining a high status and one's sibling exposure. It was only the latest born cohorts that experienced this tradeoff. On the other end of the socioeconomic distribution, there was no statistically significant relationship at all between sibling exposure and attaining unskilled status. Instead, being born into larger families became increasingly associated with ending up in skilled or lower skilled manual occupations. These results, in combination with those regarding relative mobility, suggest that the emerging quality-quantity tradeoff was being driven by a growing demand for human capital, to which parents with smaller families could more readily respond.

Figure 7. Change in probability of attaining a given socioeconomic status with respect to a one unit increase in sibling exposure.

(a) Net siblings at age 15



(b) Cumulative shared person-years until age 15



Notes: Errors bars represent 95% confidence intervals.

Source: See Results section.

Discussion

This paper has shed light on the development of the quality-quantity tradeoff during the fertility transition by examining how sibling exposure was associated with intergenerational social mobility across cohorts and socioeconomic groups. Considering the prominent role of intergenerational transfers in mainstream theories of the fertility decline (see Becker & Lewis, 1973; Caldwell, 1976; Easterlin 1975), there has been surprisingly little research on this topic.

This study has shown that family size was not associated with children's mobility outcomes later in life for those born at the start or just prior to the fertility transition. The association between the two only emerged for those born about a decade after period rates began to decline. For each cohort under analysis, the decline of period fertility had accelerated, with the final cohort (1891-1896) being born in a period with the largest decreases in period fertility up to that point. While the decline had begun in earnest in the early 1880s, it was only children born during the periods with the most rapid fertility decline that displayed a mobility penalty for being born into larger families. Furthermore, the association was only present for children with more than two surviving siblings. This finding is particularly interesting, because it was precisely the transition from the third to fourth birth that declined the greatest for the cohorts of women experiencing the fertility decline. The timing of this relationship's emergence suggests that the quality-quantity tradeoff may have only emerged after fertility began to decline. Surprisingly, those born between 1884 and 1890, the first birth cohorts of the fertility transition, showed no association between sibling exposure and mobility outcomes, despite the fact that fertility had begun declining during those years. It was only later on that the tradeoff could be identified.

The explanation offered here for why this relationship changed is that the latest observed cohorts were raised at a time in which the demand for human capital was growing. During the period of observation, both primary and secondary education became increasingly important and parents with fewer children were able to finance their children's human capital attainment better than those with more children, which, in turn, led to a negative association between family size and upward mobility. This interpretation is supported by the findings that (1) the mobility prospects of children born into higher socioeconomic strata were less influenced by sibling exposure and (2) greater exposure to siblings made it increasingly unlikely for an individual to attain a status defined by higher education. These two findings offer compelling evidence that children born into larger families in the latest cohort had, on average, lower education, which led to their reduced probability of being upwardly mobile. It should be made clear, however, that this study cannot conclusively prove that there was no quality-quantity tradeoff prior to the fertility decline, only that it did not manifest itself in the form of reduced chances of upward social mobility until after the decline began. For example, it is possible that child quality had been improving in more fundamental ways that were not measured here and may not be as closely related with socioeconomic mobility, such as via improvements in survival probabilities and general health. Indeed, these would be promising avenues of future research on this topic.

That this relationship emerged in the early years of the fertility transition presents something of a puzzle regarding the transition's causes. On the one hand, if a widespread shift towards child quality investments was responsible for the overall fertility decline, we would expect to find that the quality-quantity tradeoff would intensify at the start of the transition. This is indeed what was found. That the tradeoff was only present for children with more than two surviving siblings and that the fertility transition saw such large reductions in the transition from three to four births supports this interpretation. On the other hand, the causal role of the tradeoff does not fit some important details of the decline. For instance, the elite and lower managers groups have been identified as being forerunners in limiting their fertility (see Molitoris & Dribe, forthcoming), but the findings of this paper indicate that the tradeoff emerged simultaneously across socioeconomic groups. Furthermore, these forerunner groups' investments in child quality were the *least* sensitive to family size. So, even if the quality-quantity tradeoff has explanatory power, it remains to be seen how strong this motivation was compared to other factors (e.g. declining child mortality) for limiting fertility, particularly among forerunner groups.

The results presented here are highly consistent with the findings of previous research on the topic and contribute to illuminating the nature of the quality-quantity tradeoff during the fertility transition. As was found in Belgium (van Bavel, 2006; van Bavel et al., 2011), a negative association between social mobility and sibship size has been identified during the fertility decline. This study has also found that the association strengthened over time, as was reported for the Netherlands (Bras et al., 2010) and

England (Hatton & Martin, 2010). The present work has added to this body of literature by studying a large urban population and by more precisely identifying sibling exposure during childhood. Furthermore, it has been able to show that a socioeconomic gradient existed in which wealthier families were better able to insulate their children from the negative effects of greater sibling exposure than poorer families, suggesting a clear mechanism for why this relationship emerged.

This study, together with previous research on the topic, paints the following picture. Prior to the fertility transition, it appears that there was a weak (and possibly non-existent) child quality penalty associated with larger family sizes. For the most part, this penalty may have become manifest primarily in the form of health, but not in human capital attainment. It was only as the fertility transition gained steam that children born into larger families began to pay a larger price in the form of worse occupational outcomes. This likely was a result of the growing demand for human capital beyond compulsory levels that emerged during later phases of industrial development. Because wealthier families could subsidize their children's education through assets, access to capital markets, and personal income, their children were less susceptible, though not immune, to the negative effects of family size on their occupational outcomes. Children from poorer families, on the other hand, paid a larger price for their parents' fertility.

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Paper 3

Industrialization and inequality revisited: Mortality differentials and vulnerability to economic stress in Stockholm, 1878-1926[1]

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Abstract
This work combines economic and demographic data to examine inequality of living standards in Stockholm at the turn of the twentieth century. Using a longitudinal population register with occupational information, we utilize event-history models to show that despite absolute decreases in mortality, relative differences between socioeconomic groups remained virtually constant. The results also show that child mortality continued to be sensitive to short-term fluctuations in wages and that there were no socioeconomic differences in this response. We argue that the persistent inequality in living standards was possibly due to differences in residential patterns and nutrition.

JEL classifications: I14, I15, J31, N33, N93
Key words: Infant mortality, child mortality, socioeconomic status, urban, living standards, inequality, cost of living

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Introduction

The evolution of inequality in living standards during industrialization is one of the core themes of economic history (e.g., Kuznets 1955; Piketty 2014; Williamson 1997). And while methods and approaches to studying this process have changed over time, the discipline is primarily interested in a simple question: did industrialization reduce or widen the gap in living standards between the upper and lower classes (see Lindert and Williamson 1983; Hoffman et al. 2002; Lindert 2000)? Answering this question in a satisfactory way requires access to individual-level data, which has been a major obstacle to studying historical trends. This work contributes to the debate by utilizing a longitudinal population register for Stockholm, Sweden between 1878 and 1926 to study class differences in infant and child mortality at the height of the city's industrialization and demographic transition. Mortality at young ages has long been recognized as a valuable indicator of living standards, as it reflects important factors such as parental income, work intensity, residential conditions, access to medical care, exposure to injury and average nutrition (Mosley and Chen 1984). It also forms a core part of the Human Development Index, used for instance by the United Nations to monitor living standards globally. Furthermore, unlike other proxies for living standards, mortality data can often be found for entire populations, or at least large parts of them, while individual-level economic and anthropometric indicators are normally only available for specific occupations and sub-groups.

The present study uses infant and child mortality to shed light on the issue of living standards inequality in two ways. First, we examine the development of absolute and relative mortality differentials across socioeconomic groups. Link and Phelan (1995) argue that socioeconomic status is a 'fundamental cause' of disease, as it embodies disproportionate access to economic and social resources that can reduce exposure to and lethality of infection thereby resulting in a persistent socioeconomic gradient in health. This relationship is expected to be particularly important in a context in which the panorama of disease is changing and new medical knowledge and treatments are emerging. There were certainly large class differences in infant and child mortality in both rural and urban areas during the nineteenth century (e.g., Haines 1985, Haines 1989, Preston and Haines 1991, Breschi, Manfredini et al. 2004, Derosas 2004, Ó Gráda 2004, Bengtsson and Dribe 2010). However, it remains uncertain how those differentials developed during the later stages of industrialization, particularly in cities, where survival prospects for the young improved drastically as advances in sanitation, public health and nutrition materialized (McKeown and Record 1962, Condran and Crimmins-Gardner 1978, Szreter 1988, Beemer, Anderton et al. 2005, Burström et al. 2005). Some research has shown that, despite absolute reductions in mortality, relative class differences may have persisted over time (Antonovsky 1967, Antonovsky and Bernstein 1977, Haines 1995), but there has been little work done on the topic using longitudinal microdata, especially for urban populations. If inequality in living standards were reduced during industrialization, we would therefore expect that *relative* socioeconomic differences in mortality at young ages would have also diminished. On the other hand, a persistence of class differentials may be indicative of sustained living standards inequality.

Second, we have compiled food prices and unskilled wages for Stockholm during the period to calculate a food-adjusted wage (FAW) series, which we then use to estimate class-specific mortality responses to short-term variation in FAW. Vulnerability to short-term economic stress is a basic indicator of low living standards that has been widely used in the study of rural populations (see e.g., Bengtsson, Campbell et al. 2004, Allen, Bengtsson and Dribe 2005), and also can inform us about urban living conditions. It conceptualizes living standards as an individual's *functionings*, defined by Amartya Sen (1987a, 1987b) as the "various living conditions we can or cannot achieve" and thus differs from purely economic proxies which are viewed in terms of the implied utility one may gain from them (Bengtsson et al. 2004). If small fluctuations in the economy influenced one's risk of dying, living standards can be considered to have been quite low. This is because such a response would be suggestive of an inability to smooth consumption, a lack of access to credit or poor relief and minimal savings (Bengtsson 2004). Most studies of rural areas have found a weakening of this association by the start of our observation, but evidence from the industrial Bilbao Estuary suggests that child mortality continued to respond to changes in real wages as late as 1936 (Cagigal and Houpt 2011). Because cities in the late nineteenth and early twentieth centuries were often plagued by hostile disease environments (see e.g., Kesztenbaum and Rosenthal 2011), a worsening of nutrition could easily increase the risk of infection and death as the lethality of the most common infectious diseases among children (e.g. tuberculosis, measles, pertussis, cholera) was strongly influenced by nutrition (Lunn 1991). Estimating mortality responses to short-term economic stress can therefore allow us to evaluate inequality in living standards in terms of individual vulnerability. If such a response can be identified, we expect it should have only been present among children and not infants, as infants likely had some protection against under-nutrition via breastfeeding (see Preston and Haines 1991; Reher and Sanz-Gimeno 2004). Furthermore, there should be differences in class-specific responses to economic stress, with children of the lower classes being most sensitive and those of the upper classes remaining virtually unaffected.

Together, both of these approaches can yield insights into how the distribution of living standards developed during the industrialization and urbanization of a European capital city, which can also shed light on the experiences of other urban environments during similar stages of development.

Trends in living standards in Stockholm

In many ways, Stockholm probably was more representative of cities throughout Europe and North America than of Sweden as a whole around the turn of the twentieth century. During our period of observation (1878 – 1926) it was the largest city in Sweden with a population similar in size to cities like New Orleans, Pittsburgh, and Washington DC, and was about twice as large as the country's next biggest city, Gothenburg (Statistics Sweden 1969). Between 1870 and 1930 Stockholm grew rapidly, regularly seeing year-to-year population increases above three percent. In fact, in the 1880s the city was growing substantially faster than American metropolises like New York City, Philadelphia, and Boston. Similar to other European cities, its growth was mainly due to rural-urban migration rather than international migration.

The development of living standards in Stockholm seems to fit well with the experiences of other urban centers of the day. In economic terms, workers in Stockholm began to see sustained increases in real wages starting around the third quarter of the nineteenth century (Lundh et al. 2004; Söderberg 2010), a pattern that has also been documented for other European cities (Allen 2001). Much of these gains can be attributed as much to falling consumer prices as to steady increases in nominal wages. Between 1861 and 1913 there was little long-run change in prices in Stockholm; in fact, they even declined for several decades in the late nineteenth century (Lundh et al.

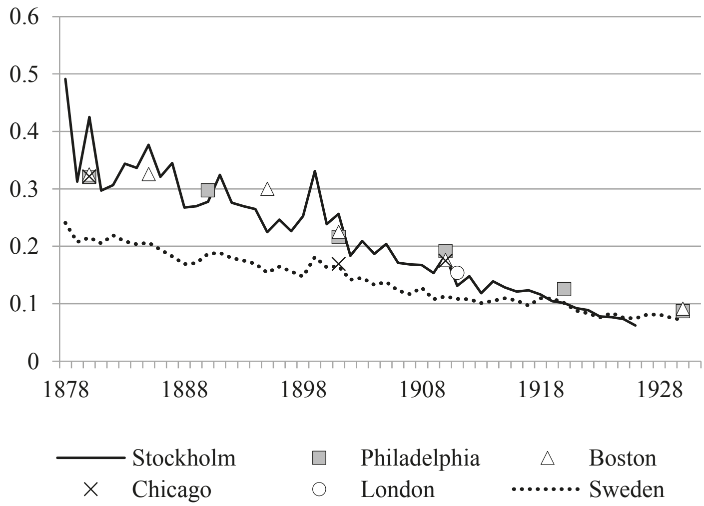
2004). Not only were economic conditions improving for the city's working classes over time, but also relative to the rest of the country. In Stockholm county, unskilled industrial real wages showed little deviation from the national average until the 1890s, when wages began to outpace those in the rest of Sweden (Lundh et al. 2004). This pattern is consistent with evidence from southern Sweden, which suggests that rural-urban differences may have been relatively small in the late nineteenth century, but increased substantially thereafter. In the southern part of the country, real wages in cities were 10-40% higher than in rural areas in the 1880s and by 1930 this difference had increased to 30-100% (Lundh 2012). Together, these improvements in individual purchasing power made living in cities attractive alternatives to rural life (see Silvestre 2005; Long 2005). It should be noted, however, that widespread unemployment and poverty continued to pose significant problems for Stockholm, as in many other urban areas, in spite of rising real wages.[2]

Trends in survival in Stockholm also reflect the experiences of other cities of the time and present a rather different view of the development of living standards. Despite the growing economic advantages of working in cities, the urban mortality penalty remained a persistent feature of industrial societies. Poor water quality, food contamination and residential crowding allowed for the proliferation of disease, and, as a result, urban mortality rates were often far greater than those of less densely populated locales. For instance, life expectancy at birth in cities of the northeastern United States remained lower than in rural areas in 1900, and major cities like Philadelphia and Chicago saw little decline in child mortality before the turn of the century (Condran and Crimmins 1980; Haines 1998). In Manchester and Liverpool, life expectancy did not even exceed 40 years by the end of the nineteenth century, and remained about 20% lower than for England and Wales as a whole (Szreter and Mooney 1998). Stockholm was no exception in this regard, as can be seen in figure 1. The probability of dying before age five during this period was remarkably similar to other large cities, despite

[2] Poverty rates of over 30% have been reported for large cities in the late nineteenth century in Stockholm (Söderberg et al.1991), Montreal (Thornton and Olson 2011) and New Orleans (Vandal 1992).

their many qualitative differences. As elsewhere, mortality was substantially higher than the national average during much of industrialization and did not converge until the early 1920s (see also Statistics Sweden 1969). Under-five survival certainly improved throughout the period, but gains were unsteady until about the turn of the century, after which year-to-year variation decreased in magnitude.

Figure 1. Probability of dying before age five ($_5q_0$) in selected populations.



Notes: The probability of dying at age 5 ($_5q_0$) is calculated as $_nq_x=2_nm_x/(2+_nm_x)$ where $_nm_x$ refers to the age-specific mortality rate for the age group x to x+n. Age-specific rates calculated per 1,000 person-years.

Source: For Stockholm, see Data section. Swedish data come from the Human Mortality Database. Estimates for Chicago, Philadelphia and Boston come from Haines (2000). Estimate for London comes from Garret, Reid, Schürer and Szreter (2001, pp. 117).

Although child mortality remained higher in Stockholm than in the rest of the country into the twentieth century, sincere attempts to address the problem were already being made by the local government by the mid-nineteenth century. In the second half of the century Stockholm's Department of Health was established, leading to the creation of the Health Police (*Hälsopolisen*), which was responsible for the strict inspection of food, housing, water and waste management. They often imposed penalties for unsanitary living conditions and provided information to individuals on how to improve their hygiene. The inspection activities of the Health Police boomed in the last decades of the century, especially regarding the regulation of foodstuffs. During the 1880s, there was an eightfold increase in the number of inspections conducted by the organization. The increased rigor of the Health Police during this time not only likely helped to diminish the transmission of foodborne illness, such as typhoid, but also helped to instill new social norms and standards among both consumers and food retailers, which resulted in increases in voluntary inspections by proprietors in the city (Rämme 2001).

During the same period, piped water was becoming increasingly common in Stockholm. In 1861, the first public water mains were opened for use, and by 1896 86% of working-class apartments had access to piped water; these improvements have been cited as a major cause of the decline of water-borne disease in the city (Burström et al. 2005). Despite its enormous importance, the expansion of Stockholm's water system is an illustrative example of how general improvements in living standards may not necessarily lead to equitable outcomes, at least in the short term. In the early phases of the system's expansion, water mains were not laid proportionately based on neighborhood populations or with the primary intention of ameliorating high risk areas. Södermalm, a largely working-class area at this time, was by far the most densely populated area of the city in 1860, as well as one of the most deadly, yet only received pipes on a couple of major streets. The districts of Gamla Stan, Norrmalm and Östermalm, on the other hand, which had high proportions of upper-class residents, had pipes installed much more extensively, being found under virtually every street by 1870 (Hansen 1897). It would take several decades for this sort of coverage to reach the poorer areas of the city. In fact, it was not until after 1896 that the entirety of Södermalm would be serviced with running water. The lag was not coincidental, as connecting individual properties to the mains was to be done at the expense of the proprietors and required substantial investments in materials, costs that most working-class families could not afford and that landlords hoped to avoid.[3] This is evident in the fact that, even within

[3] The director of Stockholm's Water Works published "*Vatten-Taxa för Stockholms Vattenledning att gälla tills vidare, samt Reglemente för Vattenledningens begagnande*", which outlined the prices and rules for use of the city's water network in 1860. The rules stated that individuals must finance their own connections to the water mains, as well as follow strict standards for the materials that may be used in their construction. While the costs of water use

Södermalm, it was the children of the upper classes who saw declines in diarrheal mortality well before other socioeconomic groups (Burström et al. 2005).

By virtually any measure living standards clearly improved in Stockholm during industrialization. Workers were earning higher wages, children were more likely to survive to adulthood and higher standards of sanitation and housing made urban life safer and more comfortable. But this study seeks to examine how the *distribution* of living standards developed alongside such changes. Did these improvements lead to more equitable conditions across socioeconomic strata? Or did they merely shift the mean without altering the distribution? By studying the development of socioeconomic differences in infant and child mortality we can provide answers to these questions.

Data

Demographic Data

The demographic data for this study come from the Roteman's archive, a longitudinal population register maintained by the city government between 1878 and 1926. The dataset is spell-based, with information on how spells began (e.g. birth, in-migration) and ended (e.g. death, out-migration). While a few less-populated parts of the city have still not been digitized, the data's population coverage is nearly complete. On 1 January 1878, the city government initiated the system in order to improve the quality of population data, which had been declining as the volume of intra-urban migration and rural-urban migration increased. The city was subdivided into administrative districts which were overseen by a registrar (*roteman*), who was responsible for recording individuals' tenancy, movements, occupation and vital events within his district (Geschwind and Fogelvik 2000). The

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would not have been prohibitive to working-class families, the initial investment certainly would have.

system was eventually disbanded in 1926 for the same reasons it was initiated, rapid population growth.

The occupational information was coded using the Historical International Standard Classification of Occupations (HISCO) and that of the head of household was used to create a social class variable for each family using HISCLASS, a 12-category classification scheme based on required skill level, degree of supervision, manual or non-manual character of work, and whether it is an urban or rural position (van Leeuwen, Maas and Miles 2002; van Leeuwen and Maas 2011). These 12 classes were then aggregated into five groups: Elite (1+2), Lower managers (3+4+5), Skilled workers (6+7+8), Lower skilled workers (9+10), and Unskilled workers (11+12). This grouping largely maintains the character of the original classification, but avoids problems of small numbers within some categories. Individuals with no occupation assigned to them and were coded as missing.

Despite its longitudinal character, a number of dates were missing or incomplete in the original data. Often there were only partial dates available, usually consisting only of a year or of a year and month. The missing dates almost exclusively were for spells that began or ended with migration, while birthdates and death dates were virtually complete. But in order to properly identify the time under exposure, it was necessary to systematize how we treated missing date information for these spells. Missing dates were assigned median exposure. That is, missing entry dates would be defined as 1 July and missing exit dates as 30 June if both the month and day were missing. If only the day was missing, the middle of the month was taken. This seems to be the most prudent solution that prevents us from overestimating exposure. Most of the infants in our analysis were born in the city and thus fewer missing dates are present (roughly 20%). Children aged one to ten, however, migrated much more often than infants and had a larger share of incomplete dates. Roughly 45% of their dates had only a year or a year and month, but using the midpoints for missing dates should at least average out problems of exposure.

Price, wage and expenditure data

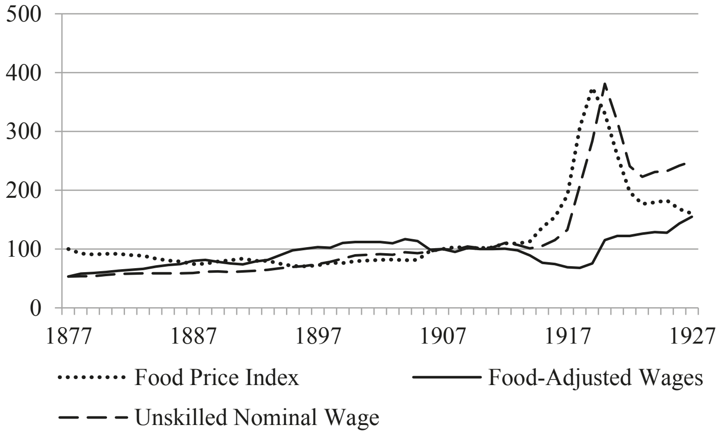
To complement the demographic data, we have collected economic information to calculate a food-adjusted wage (FAW) series. The first step in constructing the FAW series was to determine which items would be included in the food price index. The items included in the basket were those that: (1) were present in a local survey of working-class consumption

(*Statistisk undersökning angående levnadskostnaderna i Stockholm åren 1907-1908*) administered by the Stockholm City Council for the period 1907-1908 and (2) those for which price information was complete for the period 1877-1926. These restrictions allowed for the inclusion of 23 basic food items (see Appendix for full list). Prices for these items were collected from two sources. For the period prior to 1906, prices were taken from the appendix of Myrdal (1933, pp. 205-245) for Stockholm. Most of these came from prices stipulated in contracts with hospitals, orphanages, and military units, in addition to those published in local newspapers. For the period 1906-1926, annual price data were collected from Stockholm's monthly statistical reports.

The weights used to construct the food price index are based on the abovementioned survey. In 1907, households were sent booklets in which they recorded daily expenditures on a list of basic and luxury goods and the quantities and weights of purchased goods for an entire year (1 Oct 1907 – 30 Sep 1908). In total, 270 booklets were distributed with a 68% response rate. Our basket only includes the most heavily consumed commodities for which prices were available, which naturally means it is incomplete. Yet, the included items made up over 70% of household expenditures on food, so, in terms of a food budget, our basket reflects consumption rather well. According to the survey, total food costs made up between 35-50% of a household's budget, depending on income. This was by far the biggest expenditure, followed by housing (roughly 20%) and clothing (about 10%), both of which made up the nearly same proportion of a household budget regardless of income. The source material provides information on differences in consumption patterns by income groups, but because individual income categories could have small numbers of observations, the basket is weighted based on the average consumption of all income groups. This should not be problematic, however, as the survey only included working-class households and was meant to reflect the basic living costs of the city's inhabitants. Using the prices and weights above, we calculated a Laspeyres index with 1907 serving as the base year, as this is the year in which the survey was conducted.

The nominal wages used to construct the FAW series were collected from several sources. For the period 1877-1909, wages for unskilled industrial workers in Stockholm County were taken from Lundh et al. (2004). From 1910 until 1925, wages for unskilled industrial workers in Stockholm City were taken from *Engineering Works* as reported in Bagge et al. (1933, pp. 272-273). For 1926 unskilled industrial workers' wages were taken from *Sveriges Verkstadsförenings arkiv* (Association of Swedish Workshop Employers archive). After deflating nominal wages with the food price index (see figure 2), we took the natural logarithm of the FAW series and applied the Hodrick-Prescott (HP) filter with a smoothing parameter of 6.25 as suggested by Ravn and Uhlig (2002) for annual data. We then extracted the trend and its residual component (see figure 3), which will be used in the multivariate models to estimate the short-term mortality response to FAW variation. An advantage with this approach over using first differences is that the residual series measures deviations from "normal" levels, while using first differences essentially equates a change from normal to very low wages with a change from very high to normal wages. During our period of observation FAW increased nearly unabated and by the end of the period had more than tripled. The only exception to the otherwise constant growth in FAW occurred during World War I, when rapid inflation led to temporary declines. But prior to the war, food prices exhibited no substantial increases for the first three decades of our period. As mentioned above, the price of food even declined for much of the pre-war period. Later in our analysis, we will check the sensitivity of our results by controlling for those extreme years. It should be stressed, however, that the focus of our analysis is not on trends in wages and prices but to what extent people were vulnerable to short-term fluctuations in FAW, as measured by infant and child mortality.

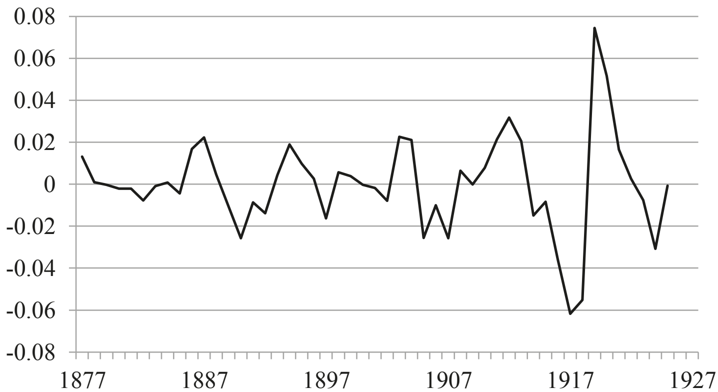
Figure 2. Food price index, nominal wages, and food-adjusted wages (FAW) for Stockholm, 1877-1927.



Notes: Year 1907 = 100 in all series.

Source: See Appendix for a complete list of wage, price and expenditure sources.

Figure 3. Deviations from medium-term trend in food-adjusted wages (FAW), 1877-1926.



Notes: The figure above shows the Hodrick-Prescott (HP) residuals which were derived from the natural logarithm of the constructed FAW series. The vertical axis is in the log scale. The residuals reflect deviations from the HP trend.

Source: See Data section.

Methods

We use event-history models to first estimate class differences in mortality and to then examine differential mortality responses to short-term variations in FAW. Before specifying the models, the respective risk populations for each model needed to be identified. Two separate sets of models are used to describe infant mortality (below age 1) and child mortality (age 1 to 9). Individuals became at risk for infant mortality either by being born in Stockholm or by migrating to the city before age one. Those born before the ledger period (1 January 1878) were not considered at risk until the ledger period began. They would be censored if they migrated out of the city before reaching age one, reached age one or the ledger period ended (31 December 1926). Individuals became at risk for child mortality by reaching age one in the city or by migrating to the city between ages one and ten. Similar to infants, they were censored upon migration, reaching age ten or surviving to the end of the ledger period. In total, these restrictions allow us to follow 255,909 infants and observe over 24,000 deaths. For children, we are able to follow 309,029 individuals and observe more than 20,000 deaths.

The above risk populations are analyzed using piecewise-constant hazard models. This is an appropriate specification for our purposes, as we are unable to incorporate age, an important time-dependent covariate, into our model as an independent variable (Blossfeld et al. 2007). Furthermore, the model does not require any assumptions of the shape of the underlying baseline hazard function. A constant baseline hazard function was assigned for four-week intervals when studying infant mortality and six-month intervals when studying child mortality. Historically, month-to-month mortality risks varied substantially in the first year of life (see Reher and Sanz-Gimeno 2004), and therefore we assign infants a unique baseline hazard for every four weeks. After the first year of life, mortality risks tend to smoothen out over the year and for this reason we only chose to assign two unique time pieces per person-year. In the case of child mortality, for example, this translates to 18 unique sub-period intercepts. A sensitivity test was performed by altering the size of these intervals (not shown) and revealed no substantial differences in the estimates.

Using these models we estimate how the risks of infant and child mortality varied between socioeconomic groups over time by interacting the socioeconomic status of the head of household with a categorical period variable, while controlling for the number of children in the household, sex, illegitimacy, district of residence and birth order. The distribution of the models' covariates may be found in table 1. We then estimated short-term vulnerability by modelling mortality as a function of the current and lagged FAW residuals as well as an interaction between FAW and class to examine how short-term economic variation influenced mortality risks for different socioeconomic groups. The same aforementioned controls were included in these models.

Table 1. Distribution of covariates used in piecewise constant hazard models.

Variable	Infant Mortality	Child Mortality
FAW Residuals	0.0	0.0
Lagged FAW Residuals	-0.0	-0.0
Socioeconomic Class:		
Elite	5.3	5.7
Lower Managers	17.4	18.4
Skilled	25.3	27.3
Low Skilled	23.4	21.9
Unskilled	23.0	23.4
Missing	5.6	3.3
Period:		
1878-1882	7.8	5.9
1883-1887	10.2	8.4
1888-1892	10.9	10.2
1893-1897	10.6	11.2
1898-1902	11.2	11.2
1903-1907	11.0	11.1
1908-1912	11.3	11.1
1913-1917	11.2	12.8
1918-1922	9.9	11.3
1923-1926	5.9	6.9

(continued on next page)

Table 1 (continued)

Variable	Infant Mortality	Child Mortality
Children in household:		
1 to 2	58.0	45.5
3 to 5	32.2	41.3
6 to 9	8.2	11.5
10+	1.7	1.7
Female	49.5	50.7
Born out of wedlock	18.3	13.0
District:		
Gamla Stan	4.2	4.0
Norrmalm	8.5	8.7
Kungsholmen	17.6	17.2
Östermalm	21.0	21.2
Södermalm-East	24.7	24.3
Södermalm-West	19.5	19.1
Brännkyrka	4.6	5.6
Observed birth order:		
1	32.7	33.8
2	21.9	23.2
3	14.9	15.3
4	10.2	9.9
5	6.9	6.4
6	4.6	4.1
7+	8.8	7.3
Individuals	255,909	309,029
Deaths	24,233	20,652
Person-years at risk	199,757.90	1,568,333.40

Notes: Means of FAW series residuals are reported and have been rounded to the nearest tenth.

Source: See Data section.

Results

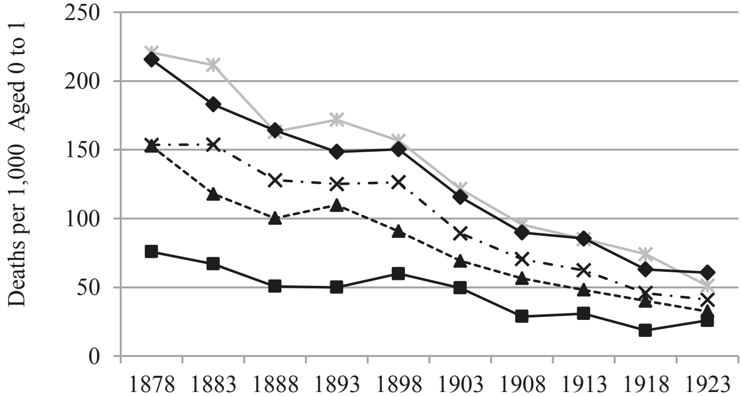
Class mortality differentials

Urban mortality during industrialization was not just a story of levels, but also of distributions. Figure 4 shows age-specific mortality rates for Stockholm by class between 1878 and 1926. Early on, the spread of mortality rates was extreme, with the upper classes experiencing far fewer infant and child deaths than the lower classes. Between 1878 and 1882 the elite had infant death rates of about 75 per 1,000 while the unskilled had rates nearly three times that. For the next half-century infant mortality declined for all groups tremendously, yet the unskilled did not reach the 1878 level of elite mortality until after World War I. The same relative differences also existed for child mortality rates. While socioeconomic mortality differentials remained even at the end of our observation, there is something to be said for the large absolute decreases in differences that occurred. By the end of the period substantial convergence occurred in absolute terms. At the start, the unskilled group lost 140 more children per 1,000 in their first year of life than the elite; this number was 'only' 35 more deaths per 1,000 by 1926. The infant death rates of the working classes declined at a faster rate than for the upper classes. For child mortality, the difference between these groups decreased from 20 deaths per 1,000 to just 2 per 1,000 by the end of the period. This evidence suggests that living standards of all, especially of the working classes, were improving tremendously.

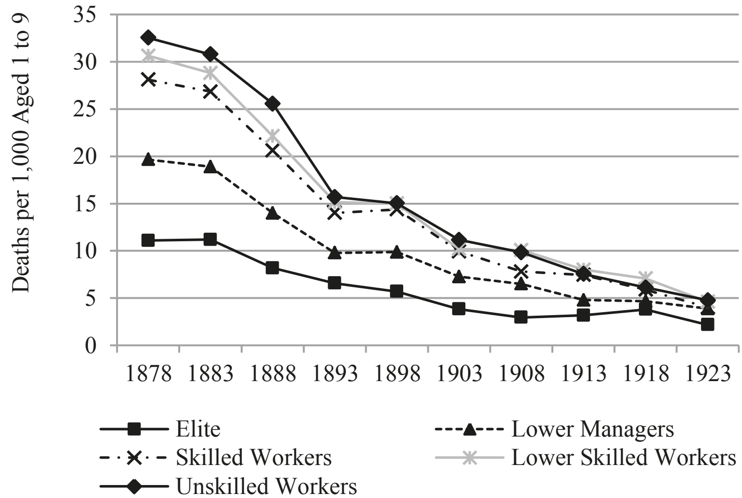
The results of the piecewise constant hazard models (see table 2) confirm the strong class gradient in mortality both for infants and children. Children of the elite had significantly lower mortality risks than other groups even after controlling for potential confounders, while those of the unskilled had the highest risk of mortality in both age groups. The relative differences were smaller for children than for infants, though they remained quite large. The missing occupational group had the highest mortality risks of all, but this appears to largely be due to a high prevalence of illegitimately born children and single mothers within the group.

Figure 4. Infant and child mortality rates by social class in Stockholm, 1878-1926.

(a) Infant mortality



(b) Child mortality



Notes: The figures show age-specific mortality rates calculated as the number of deaths per 1,000 person-years aged 0 to 1 (${}_{1}m_{0}$) for infants and aged 1 to 9 (${}_{9}m_{1}$) for children. The rates for infants differ from standard infant mortality rates, which would be the number of deaths in the first year of life per 1,000 live births.

Source: Roteman Database, see text, section 3.1.

Table 2. Hazard ratios (HR) of infant and child mortality, Stockholm 1878-1926.

	Infant Mortality		Child Mortality	
	HR	S.E.	HR	S.E.
Socioeconomic class:				
Elite	(ref)		(ref)	
Lower Managers	1.66***	0.091	1.53***	0.079
Skilled	1.98***	0.105	1.99***	0.099
Low skilled	2.37***	0.126	2.06***	0.105
Unskilled	2.41***	0.128	2.17***	0.109
Missing	5.68***	0.313	4.56***	0.254
Deaths	24,233		20,652	
Individuals	255,909		309,029	
Families	116,454		124,969	
Person-Years at Risk	199,757		1,568,333	
Log Likelihood	-102,827		-93,584	

p<0.05, **p<0.01, ***p<0. 005.

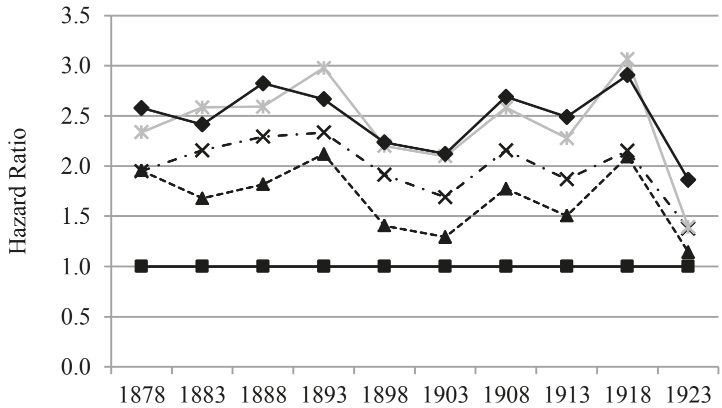
Notes: The hazard ratios and standard errors are taken from piecewise constant hazard models of infant and child mortality. In addition to the variables shown above, the models control for the number of children in the household, the sex of the child, whether or not the child was born within wedlock, the district of residence in the city, and the observed birth order of the child.

Source: The Roteman Database.

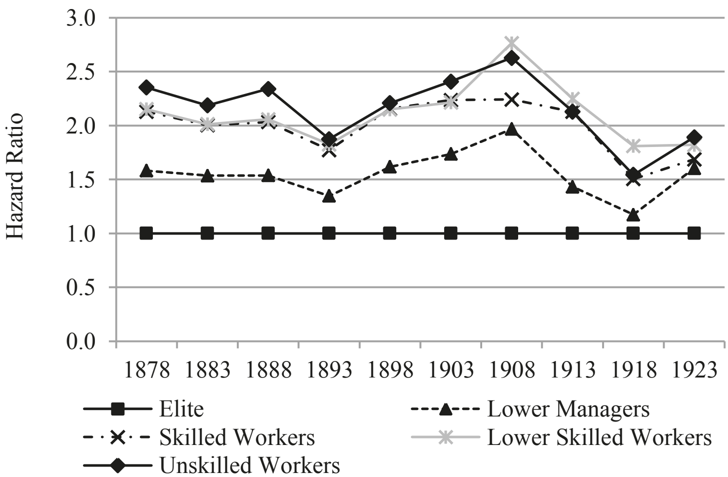
To explore how relative differences between groups evolved over time, an interaction between class and period was included for both age groups. In figure 5 it is apparent that relative differences changed little in the long run, though there was considerably more variation in the short run. For infants, slow convergence seems to have occurred for most groups but much of the reduction in mortality differentials only materialized at the end of the period, and this was not enough to eliminate the large difference between elite and unskilled workers, the latter of which still had nearly double the risk of infant death compared to the former by 1926.

Figure 5. Relative class differentials in infant and child mortality in Stockholm, 1878-1926

(a) Infant mortality



(b) Child mortality



Notes: Hazard ratios should be interpreted with respect to the reference group. For example, a hazard ratio of 2.0 indicates that the group had double the risk of infant mortality than the reference group (Elite). Results taken from an interaction of socioeconomic group and time. See Methods section for a complete description.

Source: See Figure 4.

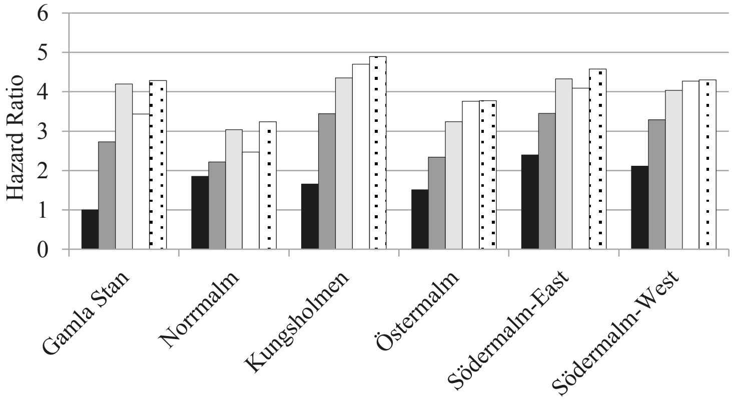
Among children, some convergence occurred as well, though by the end of the period the net reductions in the mortality gap were small for most groups; the children of lower managers even saw a slight widening of this differential. Even after substantial mortality decline in the city, all groups had between 50% and 100% higher child mortality than the elite, presenting a less rosy picture of the development of inequality in living standards than did changes in absolute differences. Even after significant changes to the urban environment, like improved access to water and major sanitation reform, fundamental inequalities in infant and child deaths more or less persisted throughout the bulk of industrialization.

It appears that this persistence was at least partially related to socioeconomic segregation within the city and the disparity of local living conditions between districts. An interaction model of social class and residential district before and after 1900 (figure 6) showed that mortality differentials between classes were present regardless of where families resided and this changed little over time, though the levels of mortality varied across districts for groups. Even the children of the elite group could not avoid the mortality penalty imposed by the unsanitary living conditions of certain parts of the city. This is evidenced by the fact that children of this group had about double the mortality risk of others from the same class living in Gamla Stan.

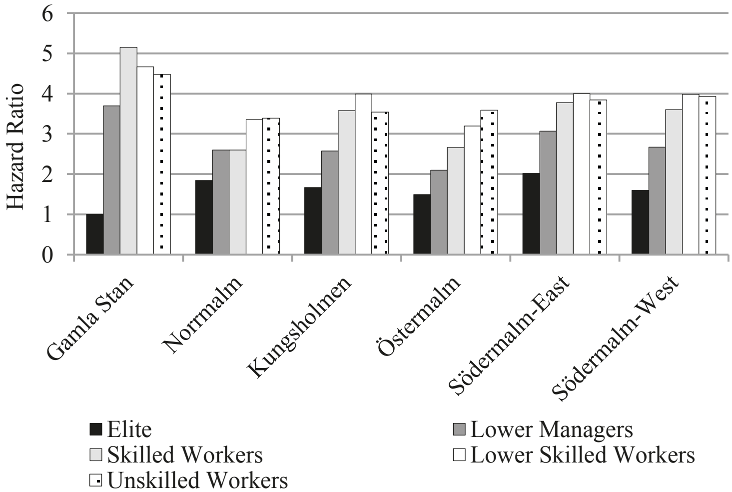
Despite the consistent socioeconomic distribution of mortality, however, the distribution of residential location differed substantially by class (tables 3 and 4). The upper classes tended to be highly concentrated in the two lowest mortality areas of the city, thereby lowering their baseline risks. Within the highest mortality areas, the working classes made up more than 80% of the population and these distributions did not change much between the two periods. Though inequalities remained even within districts, the residential patterns of these groups served to inflate the overall differences between groups. This is evident in the fact that the lowest mortality district throughout our observation, Norrmalm, displayed the most uniform risks of child mortality across classes and was the least homogeneous in terms of its socioeconomic distribution. Taken together, this suggests that living standards must have improved substantially for the working classes, as child mortality rates declined dramatically despite the fact that they became even more concentrated within higher risk areas in the later period.

Figure 6. Class differentials in mortality with Stockholm's districts.

(a) 1878 – 1900



(b) 1901 – 1926



Notes: Hazard ratios should be interpreted with respect to the reference group. For example, a hazard ratio of 2.0 indicates that the group had double the risk of infant mortality than the reference group (Elite in the district of Gamla Stan). District of Brännkyrka excluded as it was not part of Stockholm until 1913.

Source: See Figure 4.

Table 3. Distribution of socioeconomic class within Stockholm's districts by period.

(a) 1878 – 1900

	Gamla Stan	Norr-malm	Kungs-holmen	Öster-malm	Södermalm-East	Södermalm-West
Elite	4.4	9.9	2.7	8.3	1.5	2.2
Lower Managers	30.0	28.1	11.0	22.9	12.0	15.9
Skilled	29.8	29.6	30.4	27.5	27.4	31.6
Low Skilled	13.3	16.6	27.7	18.2	21.9	24.9
Unskilled	19.7	12.8	26.1	19.6	34.7	23.3
Missing	2.8	3.0	2.1	3.6	2.5	2.1
White Collar	34.3	38.0	13.7	31.1	13.5	18.2
Blue Collar	62.8	59.1	84.2	65.3	84.0	79.7

(b) 1901 – 1926

	Gamla Stan	Norr-malm	Kungs-holmen	Öster-malm	Södermalm-East	Södermalm-West
Elite	5.4	10.8	5.6	16.0	2.5	3.5
Lower Managers	24.9	28.1	16.1	24.5	14.5	18.2
Skilled	23.3	24.4	25.4	22.2	25.8	27.9
Low Skilled	17.7	19.8	25.6	16.5	23.7	25.7
Unskilled	24.2	12.9	22.7	16.7	29.3	21.0
Missing	4.6	4.1	4.6	4.1	4.1	3.7
White Collar	30.2	38.9	21.7	40.5	17.0	21.7
Blue Collar	65.2	57.1	73.7	55.4	78.9	74.7

Notes: Figures represent the share of a district's total exposure contributed by each socioeconomic group. The shares presented for the six original groups sum to 100 within each district. 'White Collar' refers to the sum of the 'Elite' and 'Lower Managers'. 'Blue Collar' is the sum of the rest, excluding the 'Missing' group. Therefore, these two categories will not sum to 100.

Source: See Table 2.

Table 4. Distribution of socioeconomic class between districts by period.

(a) 1878 – 1900

	Gamla Stan	Norr-malm	Kungs-holmen	Öster-malm	Södermalm-East	Södermalm-West
Elite	5.0	26.8	9.5	41.1	8.1	9.5
Lower Managers	8.7	19.3	9.8	28.9	16.0	17.2
Skilled	5.4	12.6	16.8	21.5	22.7	21.1
Low Skilled	3.3	9.6	20.7	19.2	24.7	22.6
Unskilled	4.3	6.6	17.3	18.4	34.7	18.7
Missing	5.5	13.6	12.6	30.2	22.4	15.6
White Collar	8.0	20.8	9.7	31.4	14.4	15.7
Blue Collar	4.4	9.8	18.1	19.9	27.1	20.7

(b) 1901 – 1926

	Gamla Stan	Norr-malm	Kungs-holmen	Öster-malm	Södermalm-East	Södermalm-West
Elite	2.6	10.2	16.2	50.7	9.8	10.6
Lower Managers	4.4	9.7	17.0	28.4	20.7	19.9
Skilled	3.1	6.4	20.2	19.4	27.8	23.1
Low Skilled	2.6	5.8	22.8	16.2	28.7	23.9
Unskilled	3.6	3.8	20.4	16.6	35.8	19.7
Missing	3.7	6.5	22.5	21.7	26.9	18.5
White Collar	3.9	9.8	16.7	34.4	17.8	17.4
Blue Collar	3.1	5.4	21.1	17.5	30.6	22.3

Notes: Figures represent the share of each socioeconomic group within a district. Rows sum to 100.

Source: See Table 2.

Mortality responses to short-term economic stress

In order to study vulnerability to short-term economic stress across socioeconomic groups, the original five classes were aggregated into 'white collar' (Elite and Lower Managers) and 'blue collar' (Skilled, Low Skilled and Unskilled) workers, as some groups had relatively small numbers of deaths in certain years. The 'missing' group was not included in this part of the analysis. Table 5 shows the percentage change in mortality risk associated with a 1% change in FAW relative to the trend, which was derived from the abovementioned interaction model.

Table 5. Mortality response to short-term deviations in food-adjusted wages (FAW). Effects of a 1% change in FAW.

	1878-1926			
	Infants		Children	
	Blue Collar Workers	White Collar Workers	Blue Collar Workers	White Collar Workers
Current FAW	-0.2	0.7	-1.4***	-1.9
Lag FAW	-0.1	0.3	-4.7***	-4.7
	1878-1926, controlling for 1917-1920			
	Infants		Children	
	Blue Collar Workers	White Collar Workers	Blue Collar Workers	White Collar Workers
Current FAW	-0.2	0.7	-1.6***	-2.1
Lag FAW	-0.1	0.3	-5.1***	-5.2

*p<0.05, **p<0.01, ***p<0. 005.

Notes: The model from which these figures were derived included all of the controls used in the previous models and used the same time-piece specifications. The percentage change was calculated as 100*(exp((b+i)*(log(1.01)-1)), where *b* is the coefficient of the base effect and *i* is the interaction coefficient. Elasticities for Blue Collar Workers are base effects of FAW from the interaction model while those for White Collar Workers are net effects (base effect + interaction effect). Levels of significance for Blue Collar Workers refer to the base effects, while the ones for White Collar Workers refer to interaction effects.

Source: See Table 2 and Appendix.

As expected, infant mortality displayed no sensitivity to short-term variation in food-adjusted wages and there was no statistically significant difference between classes in this regard. To see if the period of extreme fluctuation between 1917 and 1920 stemming from high inflation affected our results, we re-estimated the models with a dummy to control for those years. The results remained robust to the new specification.

The results for children exhibited a rather different pattern. We find that child mortality remained sensitive to wage fluctuations as late as the twentieth century. Both current and lagged FAW were negatively and significantly associated with mortality. This finding lends some support to our expectations that children would have been more sensitive to short-term economic stress, but contrasts with findings from rural areas which have shown that this type of vulnerability had disappeared by our period of observation (see Bengtsson et al. 2004; Bengtsson and Dribe 2005). Surprisingly, the results suggest that there was no significant difference in the class-specific response. Extending the model to control for the highly volatile years led to highly similar results, implying that the observed response was not a result of the distress during WWI. To further test the sensitivity of the results, we redefined FAW as a categorical variable to reflect high, low, and normal levels (+/- 1% deviation from the trend) and re-estimated the models (results not shown). Once again, the results remained robust to this specification and suggested a linear relationship between FAW and mortality; periods of low wages showed the highest mortality and years of high wages showed the lowest mortality, with normal years in-between.

The fact that there were no differences in the mortality response between the two aggregated classes presents an interesting puzzle. It would be unreasonable to suggest that children born into the upper classes were dying simply because wages for workers declined. Instead, a plausible explanation is that the disease environment tended to deteriorate in worse economic times, possibly due to the undernutrition of the poorest groups, which would eventually spread to the rest of the population. Indeed, evidence from London between 1670 and 1830 has shown that deaths from typhus, smallpox and fever tended to increase during times of high prices (Galloway 1985).

To test this explanation, we estimated Poisson models (table 6) treating the number of deaths from infectious diseases as a function of the FAW residuals and their lagged values and time, while constraining the effect of log(population) to be equal to one to account for differential exposure across years. The data were obtained from Stockholm City's Research and Statistics Office (2004) and the diseases chosen were the most common causes of death that could apply to children, which included tuberculosis, pneumonia, diphtheria, scarlet fever, measles and bronchitis. It should be noted that these are purely aggregated numbers of deaths by each cause and therefore do not allow us to delve further into how different age-groups or socioeconomic classes were affected.

The results support the possibility that periods of lower FAW also saw increases in mortality from both endemic and epidemic diseases. These diseases tended to be less common, or at least less lethal, during times of higher wages. This should not necessarily be interpreted as a causal relationship, but it serves to show why distinct social classes would exhibit nearly identical risks in mortality responses to economic fluctuations. It should be noted that, although we have identified a statistically significant mortality response, the overall effect of wage fluctuations on mortality was modest. Prior to 1900, infant mortality rates varied from year to year by 10 to 20%. During the same period, wages often only deviated from the trend by less than 1%. Similarly, while class differentials in mortality were in the range 50-100%, mortality variations as a result of short term economic stress rarely exceeded 10%. Nonetheless, the persistence of a mortality response suggests that at least some families continued to be rather vulnerable even at this late stage in Stockholm's economic development. The fact that FAW showed only small year-to-year variations explains why this vulnerability did not have a major impact on mortality.

Table 6. Cause-specific mortality response to a 1% change in FAW.

	1878-1926					
	Endemic Diseases			Epidemic Diseases		
	Tuberculosis	Pneumonia	Bronchitis	Diphtheria	Scarlet Fever	Measles
Current FAW	-0.7***	-2.4***	-1.3**	-4.0***	-6.0***	-4.1***
Lag FAW	-1.1***	-1.6***	0.5	-14.7***	-8.7***	-11.2***
Log Likelihood	-295.9	-477	-276.1	-687.9	-782.2	-1599.5
McFadden's R2	0.806	0.846	0.841	0.677	0.721	0.417
	1878-1926, controlling for 1917-1920					
	Endemic Diseases			Epidemic Diseases		
	Tuberculosis	Pneumonia	Bronchitis	Diphtheria	Scarlet Fever	Measles
Current FAW	-0.6**	-2.4***	-1.7***	-4.5***	-6.4***	-4.9***
Lag FAW	-1.0***	-1.5***	-0.4	-15.5***	-9.0***	-12.0***
Log Likelihood	-295.7	-477.0	-273.1	-684.1	-781.5	-1596.4
McFadden's R2	0.807	0.846	0.842	0.679	0.721	0.418
N	49	49	49	49	49	49

*p<0.05, **p<0.01, ***p<0. 005.

Notes: Estimates were taken from Poisson regressions on the number of deaths in different diseases. Model controls for a time trend and constrains the effect of log(population) to equal one to account for differential exposure across years. See note for Table 5.

Source: Stockholm City's Research and Statistics Office (2004) from the dataset titled *Dödsorsaker i Stockholm 1861 – 1968*. See appendix for data sources used to calculate FAW.

Conclusion

By using individual-level data for Stockholm we have been able to examine the evolution of inequality in living standards in an urban context by measuring class differences in infant and child mortality as well as class-specific vulnerability to short-term economic stress. Our results showed that while absolute class differentials in infant and child mortality declined a great deal, relative differences remained more or less unchanged throughout the period. Moreover, we find evidence that the mortality of children, but not infants, continued to respond to short-term fluctuations in FAW into the twentieth century and that there were no class-specific differences in this regard. These findings remained robust even when removing years of extreme change during World War I and testing for threshold effects.

The results show that overall improvements in living standards, as measured by better survival and rising wages, did not lead to more equitable outcomes between social strata. In terms of relative mortality differentials, the lower classes continued to be disadvantaged to the same degree as they were nearly half a century prior. While we cannot precisely identify the cause of this pattern, part of the reason was likely due to their increasing concentration in less sanitary parts of the city. As table 4 showed, the working classes became increasingly drawn to the districts of Södermalm and Kungsholmen during the period of our study, probably due to the substantially lower rents found in those parts of the city, which could be as much as 25-50% cheaper (Stockholm stads statistiska kontor 1912). In these districts, residential crowding was at its worst. In 1910, almost 90% of the apartments in Södermalm had three rooms or fewer. This is a stark contrast to the housing conditions of the lower mortality areas of the city, Norrmalm and Östermalm, where apartments of this size accounted for about 60% of the total (Stockholm stads statistiska kontor 1912). But this cannot be the entire explanation for the persistence of mortality differentials, because even within districts class differences in child mortality were large, suggesting that other fundamental factors were at work.

Other such factors may be differences across classes in nutrition and housing standards. The existence of a clear mortality response to short-term economic stress is suggestive of a population whose nutritional status was relatively fragile, at least for some groups. This conclusion is further supported by the finding that the incidence of some of the most common infectious diseases was also negatively associated with variations in FAW. It was likely the working classes who were the most vulnerable, but this in turn led to the spread of infection to other parts of the population that were less exposed, resulting in virtually identical short-term variation in child mortality between groups. If the nutritional status of working-class children was so sensitive that relatively small fluctuations in wages could elicit a mortality response, it is probable that many of them were also chronically under-nourished, leading to higher baseline risks of mortality in any given year, and this may have been a reason for the persistence of class differences during Stockholm's industrialization.

But the perpetuation of inequality should not detract from the bigger picture, for the evolution of living standards during the period was certainly a story of success. In absolute terms, the conditions of the working classes improved dramatically during industrialization. The mortality rates of their children decreased fast and although relative differences persisted, there is a substantive difference between losing 140 more children per 1,000 in their first year of life versus 35 more per 1,000. These improvements occurred in spite of the fact that many neighborhoods remained highly segregated and the working classes became increasingly concentrated in the most dense and least hygienic areas of the city. These are important details, because persistent inequality does not mean the persistence of low living standards. The working classes saw more of their children surviving beyond the first years of life, a threefold increase in individual purchasing power and greater access to hygienic living conditions. Although they may have remained worse off than the upper classes in these regards, they certainly reaped the gains of Stockholm's industrialization.

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Appendix

Price data for the years 1877 – 1905 taken from:

Myrdal, G. (1933). *The Cost of Living in Sweden 1830-1930*. London: P.S. King & Son, Ltd., pp. 205-245.

Price data for the years 1906-1927 taken from:

Stockholms Stads Statistiska Kontor. *Statistisk månadsskrift för Stockholms stad*. December.

1906 - 1920. Tab. 20. Lifsmedelspriser. p. 11.

1921 - 1927. Tab. 8. Livsmedelspriser. p. 5.

Basket weights based on:

Tab. 8. De konsumerade kvantiteterna af viktigare hushållsartiklar per konsumtionsenhet inom olika förmögenhetsgrupper (pp. 102-103). In, Stockholms Stads Statistiska Kontor. (1910). *Statistisk Undersökning angående Levnadskostnaderna i Stockholm 1907 – 1908*. Stockholm: K.L. Beckmans Boktryckeri.

Wage data for 1877 to 1909 taken from:

Table E. Index of regional nominal wages of industrial workers (p. 88). In Lundh, Schön & Svensson. (2004). *Wage formation, labour market institutions and economic transformation in Sweden 1860 – 2000.* Lund Studies in Economic History, 32. Stockholm: Almqvist & Wiksell International.

Wage data for 1910 to 1925 taken from:

Table 28. Annual earnings (in kronor) and Hourly Earnings (in öre) at Engineering Works 1903 – 1928 (p. 272). In Bagge, Lundberg & Svennilson. *Wages in Sweden 1860 – 1930. Part One.* London: P.S. King & Son, Ltd.

Wages for 1926 taken from:

Sveriges Verkstadsförenings arkiv, Teknikföretagens arkiv.

Table A. Consumed quantities and basket share of items in food price index.

Category	Item	Quantity	Unit	Basket Share
Fresh Meat	Beef	15.6	kg	6.9
	Veal	6.8	kg	2.4
	Mutton	3.0	kg	1.5
	Pork	8.1	kg	4.2
Salted Meat	Beef	2.5	kg	1.0
	Pork	12.4	kg	6.8
Salted Fish	Herring	8.7	kg	1.3
	Cod	0.8	kg	0.2
Dairy	Unskimmed	324.1	liter	21.9
	Skimmed	34.3	liter	1.0
	Butter	12.9	kg	11.8
	Cheese	5.1	kg	3.3
	Eggs	11.1	score	7.1
Flour	Wheat	47.5	kg	6.0
	Rye	2.3	kg	0.2
Grain	Oats	6.6	kg	0.9
	Rice	1.9	kg	0.3
	Barley	0.6	kg	0.0
Bread	Rye	22.3	kg	3.4
Other	Peas	2.8	kg	0.3
	Potatoes	31.8	kg	4.5
	Sugar	31.7	kg	10.3
	Coffee	6.8	kg	4.7
TOTAL				100.0

Notes: Quantities refer to the average quantity consumed per consumption unit. One consumption unit is equivalent to an adult male.

Source: Stockholms Stads Statistiska Kontor. (1910). *Statistisk Undersökning angående Levnadskostnaderna i Stockholm 1907 – 1908*. Stockholm: K.L. Beckmans Boktryckeri, pp.102-103.

Paper 4

Disparities in Death: The changing socioeconomic distribution of cause-specific child mortality in Stockholm, 1878-1926

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Abstract
The decline of infant and child mortality in the late nineteenth century is perhaps one of the greatest indicators of improving living conditions during the later stages of industrialization. Yet there is growing evidence suggesting that the substantial reductions in mortality during the era did little to reduce relative mortality differentials between socioeconomic groups (Antonovsky and Bernstein 1977, Haines 1989, Haines 2011). The aim of this study is to examine the development of socioeconomic inequalities in cause-specific infant and child mortality during Stockholm's health transition. Using an individual-level longitudinal population register for Stockholm, Sweden between 1878 and 1926, I estimate competing risks models to study how the risk of dying from five categories of causes varied across socioeconomic groups over time. The results showed that class differentials in nearly all causes of death converged during the health transition. The only exception to this was mortality from airborne infectious diseases, for which the gap between white collar and unskilled blue collar workers widened over time. Possible explanations for these patterns are discussed in the conclusion.

JEL classifications: I14, I15, J31, N33, N93
Key words: Infant mortality, child mortality, socioeconomic status, urban, cause of death, competing risks

Introduction

The greatest threats to human health and longevity in historical populations were infectious diseases caused by unsanitary living conditions and unclean food and water, and there was perhaps no group at greater risk of succumbing to these threats than children (see e.g., Mercer, 1986; Omran, 1971; Preston & Haines, 1991). Especially a scourge of industrial cities where transmission was rapid, infectious diseases caused urban mortality rates to dwarf their rural counterparts (Cain & Hong, 2009; Condran & Crimmins, 1980; Knodel, 1977). For those children who survived beyond the critical first years of life, the severe disease burden during childhood could have long-lasting impacts on their health and well-being as well as on individual economic outcomes (Bengtsson & Lindström, 2000; Fogel, 2004; Hatton, 2011; Quaranta, 2013). It therefore cannot be overemphasized how important the mortality and health transitions were in improving living standards in both the short and long run, as these changes not only led to greater life expectancy but also more years of good health. Some economists have even argued that such dramatic gains in health and life expectancy may have been important inputs into the transition to modern economic growth (Aksan & Chakraborty, 2014; Cervellati & Sunde, 2011; Fogel, 2004; Fogel & Costa, 1997; Morand, 2004).

Despite these improvements we know that reductions in child mortality were not necessarily equally distributed throughout societies. Socioeconomic disparities in mortality at younger ages were clearly present during the mortality transition, with wealthy groups often having substantially lower rates than the working classes (see Antonovsky, 1967; Bengtsson, 2004, p. 161; Breschi, Fornasin, Manfredini, Mazzoni, & Pozzi, 2011; Edvinsson, Brändström, Rogers, & Broström, 2005; Haines, 1989, 2011; Ó Gráda, 2004; Preston & Haines, 1991, p. 120). Furthermore, some evidence suggests that class differences in infant and child mortality, while changing in absolute terms, may have remained virtually constant in relative terms throughout the mortality decline, particularly between the highest and lowest socioeconomic groups (Antonovsky & Bernstein, 1977; Haines, 2011; see also paper 3). What is unclear, however, is why differentials would persist during an era in which living standards, particularly for the lower classes, seem to have been improving by most measures.

This study aims to shed light on the causes of persistent mortality inequality by examining how the declines of different causes of death varied across socioeconomic classes during Stockholm's mortality and health transitions. This is accomplished by using data from an individual-level, longitudinal population register with cause of death information to estimate event-history models in a competing risks framework. Such an analysis can be informative, as it can reveal which factors may have been responsible for the perpetuation of differential mortality and can also provide a multidimensional view of the development of living standards inequality during industrialization. Mortality's sensitivity to social, economic, and environmental conditions, particularly among children, makes it a strong indicator of living conditions, and in recent years it has been incorporated into major standard-of-living indices, such as the Human Development Index (United Nations, 1990). The advantage of studying cause-specific rather than all-cause mortality is that different causes of death can be more easily linked to their proximate determinants, which can allow one to more directly assess living standards inequality from multiple perspectives, such as differences in nutrition, access to clean water, or residential crowding. Furthermore, few studies have had access to individual-level cause of death information in historical settings, especially in an urban context. This study can therefore contribute to our understanding of the broader urban health transition as well.

Background

The decline of infant and child mortality in Stockholm did not begin until the 1860s (Edvinsson, Garđarsdóttir et al. 2008). Before then, infant mortality rates were consistently above 300 per 1,000 births, about 20% higher than the rates for the entire country at the start of its own mortality decline in the late eighteenth century. Once Stockholm's decline began, it proceeded with remarkable speed compared to the experience of Sweden as a whole. Within 50 years infant mortality rates in the city had been reduced by more than two-thirds, while the Swedish population needed more than a century to achieve a reduction of the same magnitude.

Stockholm's rapid decline was characterized by large socioeconomic differences in all-cause mortality at young ages. Several studies of infant and child mortality in different areas of Stockholm have shown that, between 1878 and 1925, manual workers had 70-100% higher infant mortality than those of the upper classes and that these differentials showed no sign of disappearing (Burström and Bernhardt 2001; Burström, Macassa et al. 2005;

see paper 3). The persistence of socioeconomic differences during this period is puzzling, as it was a time in which significant sanitary reforms had tackled many of the city's health hazards, such as unclean water and food.

Link and Phelan (1995) provide a framework to explain why, despite large declines in some of the most deadly diseases in the past, socioeconomic differences in health have persisted in the long run. They argue that socioeconomic status is a 'fundamental social cause' of disease. A fundamental social cause is one which has four main features. First, it influences multiple disease outcomes. Second, those outcomes are affected by more than one risk factor. Third, it involves one's access to economic and social resources, such as income, knowledge, political clout, and social networks, which can be used to avoid illness as well as to minimize the negative effects of disease. Fourth, the relationship between fundamental causes and health is reproduced over time as new dominant diseases emerge and as knowledge and treatments of disease are developed.

The theory of fundamental causes thus hinges on the unequal distribution of resources that individual agents can use to alter exposure to the proximate determinants of mortality. The proximate determinants include maternal factors (e.g., birth intervals, age at birth), personal illness control (e.g., medical care, personal hygiene, stress management), environmental contamination (e.g., pollution), injury, and nutrient deficiency (Mosley and Chen 1984). Resource inequality, however, will have little to no effect on inequality in specific causes of death for which the pathology and treatments are unknown (Phelan, Link et al. 2010). This is because agents will be uncertain of how to mobilize their resources in order to avoid negative health outcomes. Similarly, if investments in public health, such as the increased availability of clean water, make survival less dependent on individual resources, there should be smaller socioeconomic discrepancies in causes of death related to those sources of exposure. It becomes clear then that the degree to which each of the proximate determinants influences overall mortality differentials is not fixed, but rather varies over time as individual resources become more or less important in altering specific sources of exposure.

Although quantifying the effects of each of the proximate determinants in relation to socioeconomic mortality differentials is beyond the scope of this paper, it is worthwhile to briefly explore how the relative importance of some of these factors may have shifted during Stockholm's mortality decline.

Maternal Factors

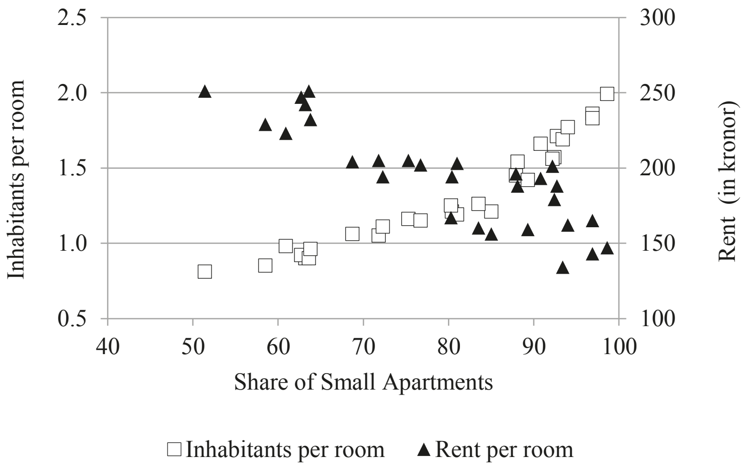
It has been shown that children born to mothers at young ages and following short intervals have a higher risk of dying (Hobcraft, McDonald et al. 1983; Hobcraft, McDonald et al. 1985), particularly from birth defects (Kwon, Lazo-Escalante et al. 2012). In historical Stockholm, these characteristics did not differ much between socioeconomic groups (see Molitoris & Dribe, forthcoming). For women born between 1860 and 1881, there were virtually no socioeconomic differences in either the mean age at first birth or the average closed birth interval. The mean age at first birth declined across these cohorts from just over 26 years old to slightly older than 24, but within cohorts class differences in the age at first birth never varied by more than a couple of months. Furthermore, in many cohorts it was actually working-class women who tended to enter motherhood later, not the upper classes. Regarding closed birth intervals, there was a more or less uniform upward trend in the mean time between births across cohorts, increasing from 2.5 to 3.3 years. This pattern was visible among women in all socioeconomic groups, and class differences in birth intervals never widened beyond three months. As with the mean age at first birth, in many cohorts it was upper-class women who were in the theoretically disadvantaged position, as they often had slightly shorter intervals than other groups. It therefore seems unlikely that systematic socioeconomic differences in maternal characteristics had an important role to play in perpetuating mortality differentials.

Personal Illness Control

Given the state of medical knowledge of the time it is also hard to imagine that differences in personal illness control would be responsible for class differences in almost any cause of death, especially prior to the twentieth century. Until the late nineteenth century, smallpox was the only major disease for which an effective therapy existed, and vaccination had already been mandatory for all Swedish children since 1816, suggesting that there should have been no socioeconomic advantage in receiving treatment. Furthermore, smallpox was practically nonexistent in Stockholm after the city's last epidemic in 1874 (Nelson & Rogers, 1992).

Tuberculosis, on the other hand, was rampant in Stockholm in the late nineteenth and early twentieth centuries (Puranen, 1984, p. 274), especially among children, yet there were no effective treatments against it. At the turn of the twentieth century, common remedies for tuberculosis consisted of living in sanatoria for months, if not years. There patients were prescribed to breathe fresh air and take walks (Wallstedt & Maeurer, 2015). The only way that access to these facilities may have influenced mortality would have been by removing infected individuals from their families, thereby limiting their exposure. Considering that these were typically small institutions, their influence on mortality inequality was limited.

Figure 1. Inhabitants per room and rent per room by the share of small apartments in Stockholm's districts, 1910.



Notes: 'Small apartments' refers to apartments with one to three rooms and a kitchen.

Source: Stockholm Stads Statistiska Kontor. (1912). Statistisk Årsbok för Stockholms Stad 1912 (1910, 1911). Kartogram 2, 3, & 5.

Environmental Contamination

Differences in environmental exposure to disease were likely much more important for sustaining mortality inequality across socioeconomic groups than maternal factors or medical care. As examples, let us consider two common environmental sources of disease: unclean water and residential crowding. The early phases of the expansion of Stockholm's water network disproportionately favored the wealthier neighborhoods in Stockholm. The city's first water mains were laid in 1861, primarily near the royal residence and in the well-to-do surrounding areas. Several water pumps were distributed throughout the city and could be used free of charge, but for direct access to the home, individual property owners were responsible for financing connections to the main network. This served as an entry barrier to many working-class families and resulted in early declines in child mortality from waterborne diseases among the city's wealthier inhabitants relative to other socioeconomic groups (Burström, Macassa et al. 2005). Compounding the problem was that most working-class areas of the city did not have any water mains until several decades after the first pipes were laid (Hansen 1897), meaning that, even if families in these areas could afford to have direct access to clean water, they did not have the possibility of doing so without moving to more expensive districts. By around the turn of the twentieth century, piped water had reached most of the population and, as a result, infant and child mortality from some waterborne diseases seems to have equalized across socioeconomic groups (Burström, Macassa et al. 2005), indicating that individual resources had become less important in securing clean drinking water than previously.

As water access improved, residential crowding increasingly became a characteristic of the working classes, leading to heightened risks of airborne infection (e.g. measles, tuberculosis). In the districts of Kungsholmen and Södermalm, two heavily working-class districts, over 90% of apartments were classified by the city government as 'small apartments' (i.e. one to three rooms and a kitchen) in 1910 (Stockholm Stads Statistiska Kontor, 1915). On the other hand, in the wealthy districts of lower Norrmalm and Östermalm much fewer apartments that fit this description (about 69 % and 63% respectively). Though the number of small apartments is not in itself a sign of poor living conditions, it is a good indication of the potential for residential crowding. Figure 1 shows that the share of small apartments in Stockholm's districts in 1910 had a strong positive correlation with the number of inhabitants per room. Unsurprisingly, districts with a large share of small apartments also tended to have lower rents per room as well, suggesting that individual resources continued to be extremely important in avoiding exposure to diseases associated with crowding.

Nutrient Deficiency

Finally, nutritional differences in terms of the quantity and quality of calories consumed varied considerably between socioeconomic groups and may have also played an important part in perpetuating mortality differentials. Many of the deadly diseases that plagued Stockholm were highly influenced by their host's nutritional status and especially their protein consumption (Rice, Sacco, Hyder, & Black, 2000). These included some of the most lethal airborne killers, like tuberculosis, measles, and pertussis (Lunn, 1991). A survey conducted in 1907-1908 concerning the consumption patterns of working-class households in Stockholm showed that, as one would expect, wealthier families spent much lower proportions of their income on food, but also consumed about 20% more protein per capita (Stockholms Stads Statistiska Kontor, 1910). It appears that this discrepancy widened during the first decades of the twentieth century. Despite improvements in nutrition for all income groups, a similar survey conducted in 1922 showed that the gap in protein consumption had increased to about 30% (Stockholm Stads Statistiska Kontor, 1927), suggesting that nutritional inequality persisted in Stockholm well into the twentieth century.

The above discussion highlights the dynamic nature of the relationship between individual resources and exposure to the proximate determinants of mortality. It also suggests that, even if overall mortality differentials may have remained constant during the mortality decline, the underlying distribution of causes of death should have shifted over time. In particular, causes that were more highly dependent on personal resources, such as airborne diseases via housing and nutrition, should have become more differentiated along class lines than those for which resources became less advantageous, such as waterborne disease due to the expansion of the municipal water supply. The following sections will examine how the distribution of causes of death changed between 1878 and 1926 and how socioeconomic differences in specific causes evolved.

Data

This study uses longitudinal, individual-level data from the Roteman Database, which is maintained by the Stockholm City Archives. The data were collected between the years of 1878 and 1926 and include all individuals who lived in the city during that time. This was done by dividing the city into districts which were each assigned an administrator to maintain the local records. Administrators would record all movements to and from their district and also events such as births, deaths, and marriages. Individuals would be entered into the local registers upon entering a district and their information would be updated annually at the time of census registration (Geschwind & Fogelvik, 2000). For each individual in the database there is information on birth date and place, location of residence within Stockholm, occupational titles, sex, and position in the household (i.e. servant, lodger, child, etc.). The present work will utilize a subsample of the database that contains individual-level causes of death in addition to the abovementioned information.

Socioeconomic groups were defined by the occupation of the head of household, which could be mothers, fathers, or, in rare circumstances, another relative if the child was adopted. Occupations were coded using the Historical International Standard Classification of Occupations (HISCO) (van Leeuwen, Maas, & Miles, 2002) and then classified according to HISCLASS (van Leeuwen & Maas, 2011), which groups occupations according to the level of skill required, the degree of supervision, and the rural or urban character of work. The original HISCLASS scheme produces 12 distinct categories of workers. However, to avoid problems with small numbers in the multivariate analysis later on, these 12 categories have been condensed into three: (1) white-collar/non-manual workers (HISCLASS 1-5), (2) skilled manual worker (HISCLASS 6-8), and (3) low skilled/unskilled manual workers (HISCLASS 9-12). In addition, a fourth category was included for those who had no occupational information available.

The data used in this study were extracted from the larger database and include all children observed in the city between birth and age 10 during the coverage period as well as any individuals sharing the same household (e.g. family members, boarders). In total, 266,444 children and nearly 37,000 deaths can be observed between 1878 and 1926. Individual cause of death information is available for about 19,000 children, or 51% of observed deaths. The large number of deaths missing a recorded cause is due to the fact that only a portion of records have been digitized at this point. The only selection that was introduced into the digitization of death records was that it was based on one's district of residence in Stockholm at the time of death. As a result, half of the 28 digitized districts have at least some cause of death information available. Of these, most have at least 50% of child deaths with a recorded cause, though in three districts the figure is much lower (about 15-20%). In some cases, primary and secondary causes of death are listed. Because this was by no means the norm, this study only utilizes primary cause of death information.

Historical sources on causes of death are not without their problems (see e.g., Risse, 1997; Rosenberg, 1989). Besides changing definitions of diseases over time, changes in administrative procedures can also affect both the quality and quantity of reporting. Starting in 1749, parish priests in Sweden were required by the Tabular Commission (*Tabellverket)* to record this information when their parishioners died (Rogers, 1999). The difficulty in correctly identifying many causes of death, in addition to the time constraints faced by priests as a result of their wide-ranging responsibilities, could at times lead to under-registration of causes and ambiguous terminology. By the time the present data began (i.e. 1878), the Central Bureau of Statistics (*Statistiska centralbyrån)* had required for nearly twenty years that urban cause of death information was to be based on death certificates signed by a physician (Rogers, 1999). Although this does not ameliorate all problems with the data, it suggests that that information present in the records should be as reliable as one could expect.

Individual causes of death were classified by mode of transmission using the scheme proposed by Bengtsson and Lindström (2000). The scheme was developed for another historical Swedish population and was more successful in classifying the causes of death for Stockholm than contemporary classification systems (e.g. ICD-10), especially regarding obsolete medical terminology. Their classification system contains nine categories which capture deaths from airborne, food and waterborne and other infectious diseases, as well as non-infectious causes, such as cancer, accidents, and diabetes, and unspecified causes. This paper has condensed these from nine to five categories: (1) airborne infectious diseases, (2) food and waterborne infectious diseases, (3) non-infectious diseases and accidents, (4) congenital malformations, and (5) unspecified causes. Of those categories with defined causes of death, airborne infectious diseases were by far the largest group (table 1). This category included common killers like pneumonia, diphtheria, and tuberculosis. The next largest was the non-infectious disease category, the size of which is more a result of aggregation than incidence. It included a wide-ranging combination of conditions and diseases, such as cancers, accidents, and chronic digestive disorders, all of which were relatively uncommon in isolation. The food and waterborne group was the third largest and contained diseases such as cholera and typhoid fever, and the smallest defined group was a collection of congenital malformations.

Table 1. Examples of diseases and conditions present in cause of death categories and their distribution.

	Percent	Disease/Condition
Airborne Infectious Disease	30.4	Pneumonia, Bronchitis, Scarlett Fever, Diphtheria, Tuberculosis
Food and Waterborne Infectious Disease	7.4	Gastroenteritis, Cholera, Diarrhea, Typhoid Fever, Dysentery
Non-infectious Disease and Accidents	9.1	Accidents, Convulsions, Rickets, Nephritis, Cancer
Congenital Malformations	3.9	Premature birth, Sclerema neonatorum, Cleft Palate
Unspecified or Ambiguous	49.2	

Notes: Percent column refers to the percentage of deaths among individuals age 0 to 9.

Source: See Data section.

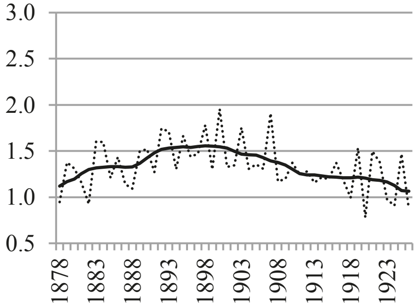
Patterns and Trends in Child Mortality in Stockholm

Between 1878 and 1926, the relative difference in age-specific mortality rates between high and low socioeconomic status groups remained virtually unchanged. Figure 2 shows the development of mortality rates for the age groups 0-1 and 1-9 of the two manual worker groups in relation to those experienced by white collar workers. At the start of observation, under-one mortality rates for skilled workers' children were only about 10% higher than white collar workers' (panel a). As mortality declined, this gap widened until around 1900, when the trend was reversed. By the end of the data's coverage, the differences between skilled and white collar workers had begun to converge. This pattern of divergence and convergence was quite different than that exhibited by lower skilled groups (panel b). The mortality rates for children below age one of low and unskilled workers consistently were about 70% higher than those of white collar workers and even showed signs of slow divergence over time.

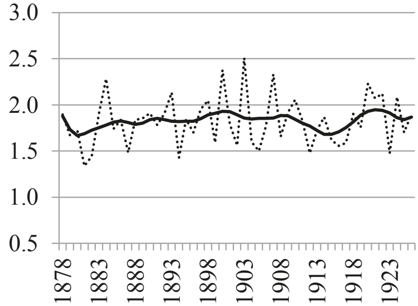
Figure 2. Infant mortality rates relative to white collar workers by socioeconomic group.

I. Age 0 to 1

(a) Skilled Workers

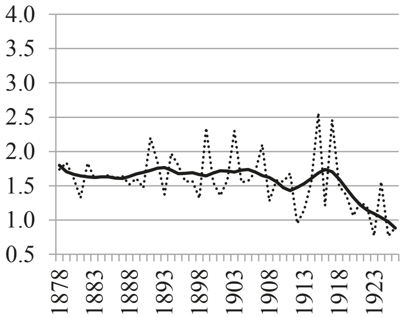


(b) Low and unskilled workers

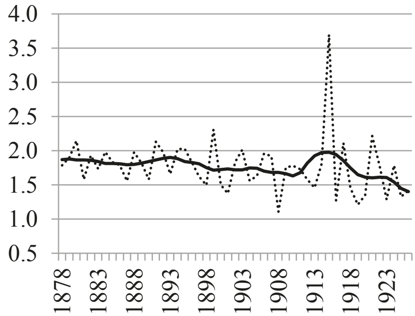


II. Age 1 to 9

(c) Skilled Workers



(d) Low and unskilled workers



Notes: Figures presented above are the ratios of the corresponding class's infant mortality in each year to that experienced by the white collar groups. A locally weighted regression was used to estimate the smoothed trend using a bandwidth of 0.25 (solid line) and has been superimposed to clarify the long-term developments of the mortality differentials.

Source: See Data section.

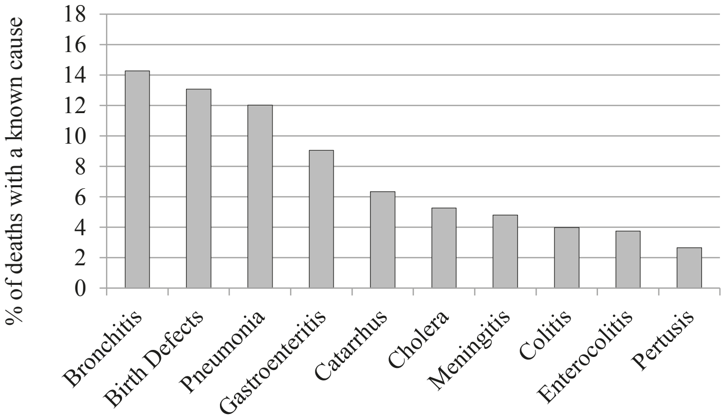
Mortality differentials for children between ages 1 and 9 developed somewhat differently. The children of skilled workers consistently had mortality rates about 60% higher than those of white collar workers until around the time of the First World War, after which rates between the groups rapidly converged (panel c). The mortality rates of low and unskilled workers' children, on the other hand, began to show signs of slow convergence towards the rates of white collar workers, but continued to have about 50% higher mortality rates by 1926 (panel d).

Explaining why this pattern remained so stable, especially between the lower skilled groups and white collar workers, first requires an understanding of how the panorama of disease evolved during the mortality decline. Although Stockholm's children were exposed to an array of deadly diseases during the late nineteenth and early twentieth centuries, only a handful was responsible for the great majority of deaths. Figure 3 shows the ten most common causes of death among infants and children between 1878 and 1926. For infants, these ten causes made up about 75% of all deaths with a known cause, while for children they accounted for almost 80%. Airborne and gastrointestinal diseases as well as birth defects were the most common killers among infants. Children, on the other hand, almost exclusively succumbed to airborne infections. In fact, just four causes (meningitis, pneumonia, scarlet fever, and diphtheria) accounted for over 50% of all deaths for children in the age group 1-9.

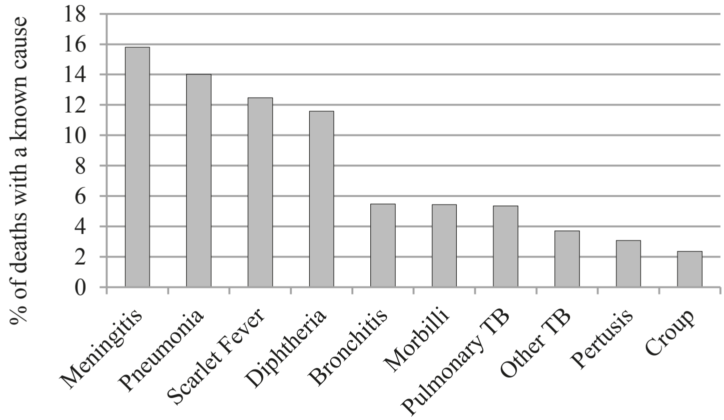
For both infants and children, the period of observation witnessed large declines in overall and cause-specific mortality (figure 4). Among infants, the importance of certain types of diseases varied significantly over time. Until the early-1880s, food and waterborne diseases were the most deadly, with rates just over 60 per 1,000. Mortality from food and waterborne illness decreased rapidly as did mortality from noninfectious diseases in the late nineteenth century. Mortality from airborne infections, on the other hand, remained stubbornly high until near the turn of the twentieth century, when it began its dramatic descent. The other major threat to infant survival, congenital malformations, was also persistent until around the same time.

Figure 3. Ten most common causes of death as a percentage of all deaths with a known cause for infants and children.

I. Age 0 to 1



II. Age 1 to 9



Notes: Figures do not include deaths from unknown causes. For infants, the ten most common causes account for 75.2% of all deaths with a known cause (n = 10,515). For children, this figure is 79.3% of all deaths with a known cause (n = 8,547).

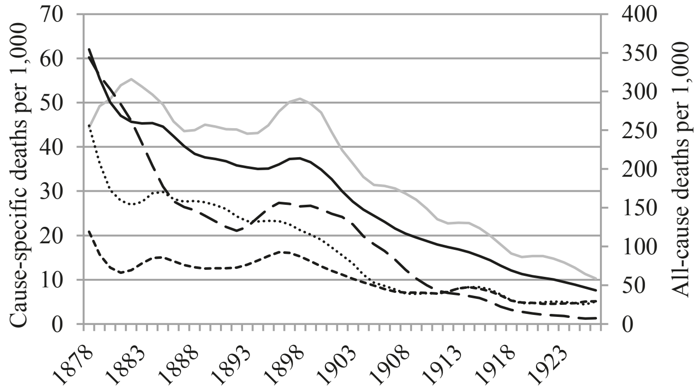
Source: See Data section.

Virtually all major infectious diseases saw short-term resurgence around 1899 during a measles epidemic, but decreased quickly again thereafter. By the end of observation all cause-specific mortality rates had decreased by at least 75% and the relative importance of each cause changed considerably. Deaths from food and waterborne diseases became the smallest group of all causes, whereas airborne infectious diseases had become the most common cause of death by a substantial margin. Infants living in 1926 were about two times more likely to die from airborne infection than from either congenital malformations or noninfectious diseases and about ten times more likely than from food or waterborne diseases.

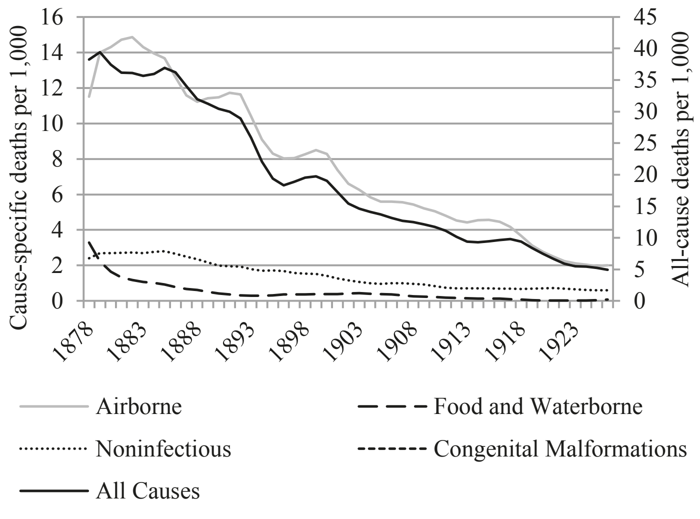
The distribution of causes of death among children (age 1 to 9) was much different than that of infants. Airborne diseases were easily the most common cause of death during the entire period, with rates about seven times larger than any other group of causes. Food and waterborne diseases had apparently been declining for some time prior to the start of observation, as the trend can be seen reaching a low plateau early on in this data's coverage. Mortality from noninfectious diseases and accidents declined quite gradually throughout the period and was nevertheless quite low at about 1 to 3 per 1,000. From this figure it is clear that the decline of child mortality was predominantly due decreasing airborne disease mortality. For infants, on the other hand, the mortality decline was characterized by sequential decreases in different groups of causes. Early on, decreases in food and waterborne mortality and deaths from noninfectious disease were largely responsible for improvements in infant survival, while later in the decline it was decreasing mortality from airborne diseases and congenital malformations that became relatively more important.

Figure 4. Locally weighted smoothed estimates of infant (age 0 to 1) and child mortality (age 1 to 9) by cause of death.

I. Age 0 to 1



II. Age 1 to 9

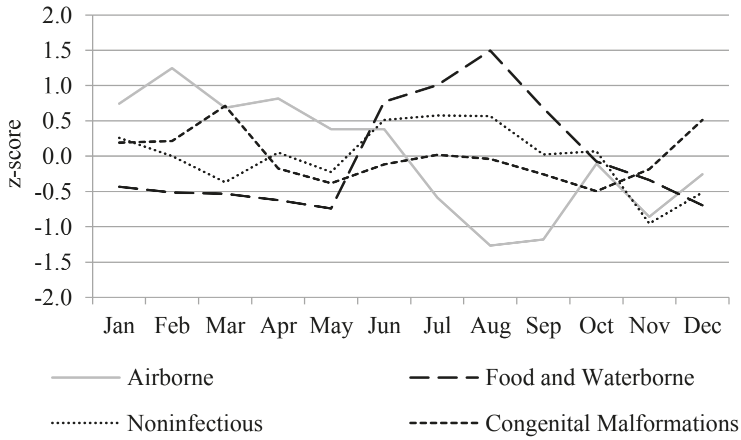


Notes: Estimates were obtained using a locally weighted regression with a smoothing bandwidth of 0.2 for annual data. Rates are calculated per 1,000 person-years.

Source: See Data section.

Over the course of any given year during this period each group of infectious diseases was more or less active depending on the mode of transmission and the season. Figure 5 presents the seasonal distribution of mortality by cause of death as z-scores. As one would expect, food and waterborne diseases were much more prevalent during the warm summer months when water consumption increased and food spoiled more quickly. Deaths from these diseases tended to rise quickly in June and reach a peak in August, which was on average 1.5 standard deviations larger than the mean mortality rates from these causes. Airborne diseases, in contrast, showed the opposite pattern. During the colder months when individuals spent more time indoors, airborne diseases were in season. Other causes of death showed much less seasonal variation. The cluster of noninfectious diseases tended to be more lethal in the summer months, but only slightly, and deaths from congenital malformations were fairly consistent throughout the year, though March tended to have elevated risks for this cause throughout the period.

Figure 5. Average seasonality of causes of death among children (age 0 to 9) 1878-1926.



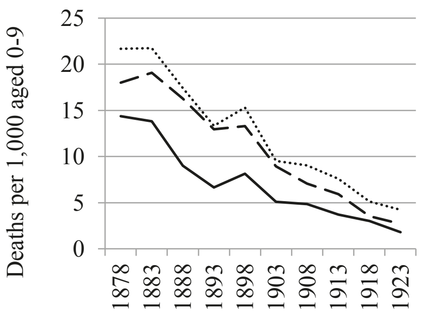
Notes: Figures obtained by calculating the mean and standard deviation of mortality rates of each cause for each year. These numbers were used to estimate z-scores for each month between 1878 and 1926. The z-scores were then averaged by month to produce the above estimates. They may be interpreted as the average number of standard deviations a month's mortality rate differed from annual average (i.e., z = 0). Congenital malformations were estimated for age 0 to 1. All other causes were estimated for ages 0 to 9.

Source: See Data section.

Not only did cause-specific mortality vary throughout the year, but also across socioeconomic groups. Figure 6 presents cause-specific mortality rates for ages 0-9, except for congenital malformations, which reflects ages 0-1 as no children beyond age one died from this cause. White collar workers had lower mortality from all causes and the difference was most apparent for airborne diseases. As overall mortality declined, some causes of death appear to have converged across socioeconomic groups. This is especially clear for food and waterborne and noninfectious diseases. On the other hand, class differences in airborne disease mortality and congenital malformations continued to exist until the end of observation in 1926, suggesting that these causes may have become relatively more important than other causes in perpetuating socioeconomic mortality differentials. But the rates presented so far have not taken into account many of the other characteristics that may be important for explaining mortality differentials besides socioeconomic status. In order to examine these differences more closely, I will use event-history models to examine mortality differentials while controlling for individual and household characteristics.

Figure 6. Cause-specific death rates per 1,000 person-years in ages 0-9 by socioeconomic status.

(a) Airborne



(b) Food and Waterborne

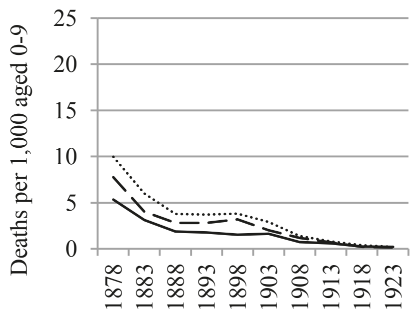


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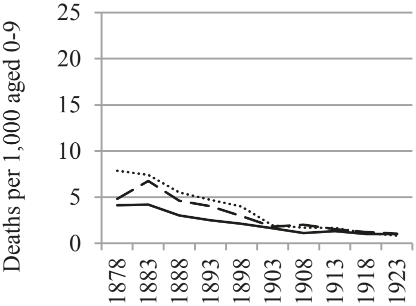
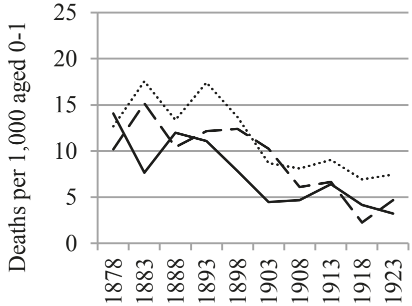
Figure 6 (continued)

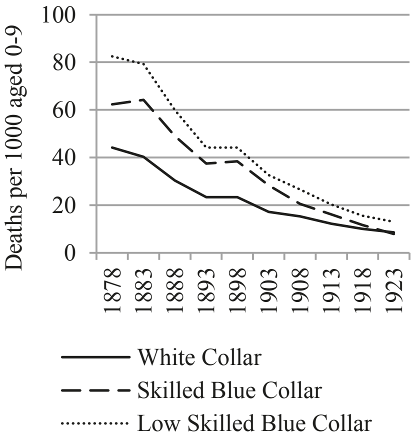
(c) Noninfectious



(d) Congenital Malformations



(e) Overall



Notes: Panel d) refers to the only age 0 to 1. Panel e) includes all deaths, including those without a specified cause. Rates calculated per 1,000 person-years.

Source: See Data section.

Multivariate Methods

In order to successfully implement an event-history analysis it is necessary to accurately identify the population at risk. For this study, individuals who were ever present in Stockholm between ages 0 and 10 were included in the analysis. This age grouping was taken to avoid problems with small numbers when including interaction terms in the models. Because causes of death have not been digitized for all districts in Stockholm only individuals in those districts with recorded causes will be considered at-risk. As a result, individuals may become at-risk only if they were living in any of the included districts between the specified ages. This means that a child would be right censored if they moved out of one of these districts before reaching age 10, even if they still resided in Stockholm. They would not be censored, however, if they moved from one district with cause of death information to another with that information. Individuals could also be left-truncated if they were born outside of the analysis districts and moved into one of them before reaching age 10.

To analyze how socioeconomic inequalities in cause-specific mortality evolved during industrialization, this study adopts a competing risks framework. Standard semi-parametric event-history models are a useful way of analyzing covariate effects on mortality risks within a population for which longitudinal information is available. Furthermore, they can easily deal with individuals being censored prior to death. One of the crucial assumptions of these models, however, is that censoring does not influence failure times. For example, assume that we were interested solely in the risk of all-cause child mortality between 1878 and 1926 and that all children could be fully observed until either death or the end of the observation period. In this case, any censoring that occurred due to the termination of the study period should have no bearing on a child's risk of dying. In the study of cause-specific mortality, on the other hand, multiple possible causes of death can violate this assumption. If one is interested in the cause-specific hazard of dying from tuberculosis, but some individuals are censored because they die from cholera, then obviously censoring will not occur independently of failure times, as dying from one cause will make it impossible to die from another.

For this reason, I will examine cause-specific mortality using Cox proportional hazards models, such that:

$$h_i^J(t) = h_0^J(t)\exp(\beta X_i)$$

where $h_i^J(t)$ is an individual's instantaneous risk of dying from cause J at time t. This is determined by the product of the baseline hazard of dying (h_0^J) from cause J and a vector of covariates, $\exp(\beta X_i)$. To estimate this model, separate Cox regressions are fit for each cause of death. This means that five models were estimated with the following binary dependent variables: deaths from (1) airborne disease, (2) food and waterborne disease, (3) noninfectious disease, (4) congenital malformations, and (5) unknown causes. By using Cox models in a competing risks framework, deaths from causes other than the cause of interest for each regression are treated as a form of censoring. This differs from the competing risk model offered by Fine and Gray (1999), which allows individuals dying from competing causes to remain in the risk population (they would remain at risk infinitely for all causes but that from which they died). Because this study is primarily interested in the effect of specific covariates on the cause-specific hazard of dying, instead of the probability of dying from one cause in the presence of other causes, Cox models are the most suitable alternative (Gaynor et al., 1993).

The models are primarily interested in how socioeconomic status influenced the risk of dying from each cause and how differences between groups developed over time. The main independent variable is socioeconomic status as defined previously. In addition, the models account for potential confounders by controlling for the month of the year, birth order, sex, illegitimacy status, district of residence, and the number of other individuals in the household. To examine how the association between class and causes of death evolved, the models were then extended by including interactions between social class and period dummies. Summary statistics of the covariates may be found in table 2.

Table 2. Distribution of Covariates.

Variable	Mean	Variable	Mean
Socioeconomic Status:		Birth order	2.6
White Collar	20.5	Female	50.4
Skilled Workers	26.4	Born out of wedlock	10.4
Low and Unskilled	47.0		
Null	6.2	District:	
		Gamla Stan	6.4
Period:		Kungsholmen	28.1
1878-1882	6.2	Sodermalm East	36.6
1883-1887	8.1	Sodermalm West	28.9
1888-1892	10.1		
1893-1897	11.3	People in household:	
1898-1902	11.6	1 to 3	14.3
1903-1907	11.4	4 to 6	44.5
1908-1912	12.1	7 to 9	25.9
1913-1917	12.3	10+	15.3
1918-1922	10.8		
1923-1926	6.2		

Notes: Percentage distribution of categorical covariates is presented. For birth order, the mean value is presented.

Source: See Data section.

Event-History Results

Table 3 shows the results of the Cox models with no interactions. Here it is clear that a socioeconomic gradient existed for mortality from each cause of death in favor of the children of white collar workers. The differences between groups were largest for the airborne disease category. From this particular cause, the children of skilled blue collar workers were more than 50% more likely to die than those of white collar workers and the gap was even larger among the low and unskilled blue collar workers, whose children had about 76% higher risks of dying from airborne diseases. For other causes of death, the differences between groups were smaller, but still significant in both statistical and real terms. Surprisingly, even deaths from congenital malformations were unequally distributed throughout the socioeconomic classes. Because the period of study is one in which prenatal care was virtually absent, the existence of a socioeconomic gradient with respect to congenital malformations may reflect differences in maternal nourishment and health.

To explore these relationships further, an interaction term between socioeconomic status and time was included in the model (Figure 7). It is clear that the evolution of socioeconomic inequality in mortality varied substantially for different causes of death. Children of white collar workers were clearly the least likely to die from airborne diseases and this advantage largely persisted over time. Towards the end of the period the risks of skilled workers' children had approached convergence with those of the reference group. The gap between low and unskilled workers' children and the reference group, however, widened between 1878 and 1926. In the first decade of observation, children from the lowest class were about 50% more likely to die from airborne illness than children of the highest class. By 1926, they were well over twice as likely to die from these diseases. This pattern was quite different from the development of inequality in other causes of death.

Mortality differentials from food and waterborne illness declined in the long run, but only after diverging for several decades. Between 1878 and 1882, both groups of blue collar workers were about 45% more to die from these diseases. But the gap between the white collar workers and the other groups widened in the following two decades before declining and eventually converging by the early twentieth century, first for skilled workers and later for low and unskilled workers. This result conforms to the findings of Burström, Macassa et al. (2005), who also documented a widening and subsequent closing of diarrheal mortality differentials between socioeconomic groups in Stockholm in the same period. It is also suggestive of class differences in gaining access to piped water, in which wealthier households were earlier users of sanitation infrastructure than poorer households, likely due to the high costs of connecting buildings to water mains in the earlier years of the water network.

Table 3. Cause-specific hazard ratios from Cox proportional hazards models.

	Airborne	Food and Water-borne	Non-infectious	Congenital Malformations	Unknown
Socioeconomic Status:					
White Collar	1.00	1.00	1.00	1.00	1.00
Skilled Workers	1.56***	1.36***	1.36***	1.24**	1.35***
Low and Unskilled	1.76***	1.55***	1.44***	1.38***	1.47***
Null	1.15***	1.13	1.04	1.11	1.36***
Birth order	0.91***	0.88***	0.87***	0.90***	0.91***
Female	0.96**	0.97	0.80***	0.83***	0.83***
Born out of wedlock	1.68***	2.28***	1.98***	2.02***	2.68***
People in household:					
1 to 3	1.00	1.00	1.00	1.00	1.00
4 to 6	1.20***	1.07	1.03	1.06	0.94***
7 to 9	1.49***	1.28***	1.35***	1.38***	1.06**
10+	1.45***	1.23***	1.35***	1.14	1.06*
Failures	10,886	2,632	3,166	1,248	17,153
Individuals	265,200	265,200	265,200	265,200	265,200
Person-Years at risk	1,046,881	1,046,881	1,046,881	1,046,881	1,046,881
Chi2	6,677.8	3,491.7	2,352.2	713.9	12,722.9

* Denotes significance at the 10 percent level

** Denotes significance at the 5 percent level

***Denotes significance at the 1 percent level

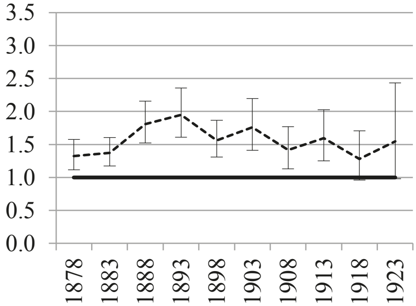
Notes: A cause-specific hazard ratio of 1.5 indicates that the instantaneous risk of dying from the selected cause is about 50% higher than the reference category. For full model specification and inclusion criteria, see Methods section. Estimates of period and month hazards have been omitted from the output.

Source: See Data and Methods sections.

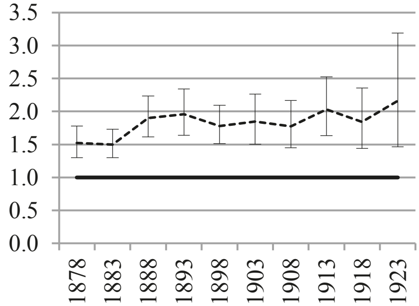
Figure 7. Socioeconomic differences in cause-specific mortality 1878-1926.

I. Airborne

(a) Skilled Workers

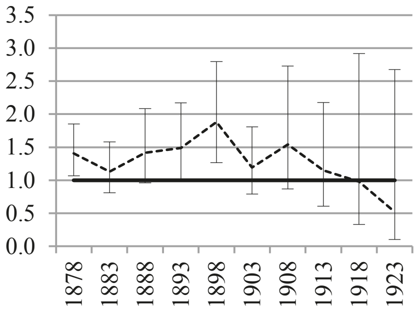


(b) Low and Unskilled Workers

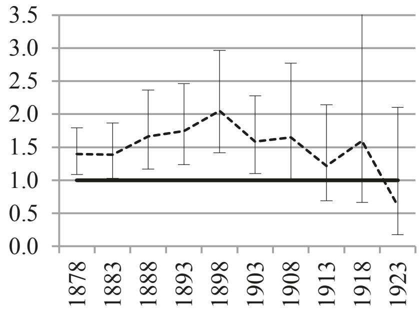


II. Food and Waterborne

(a) Skilled Workers

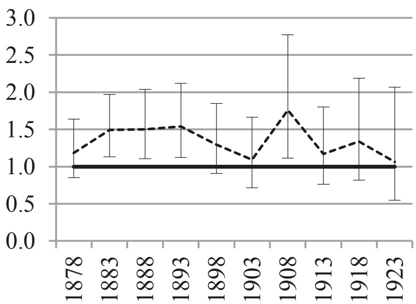


(b) Low and Unskilled Workers



III. Noninfectious

(a) Skilled Workers



(b) Low and Unskilled Workers

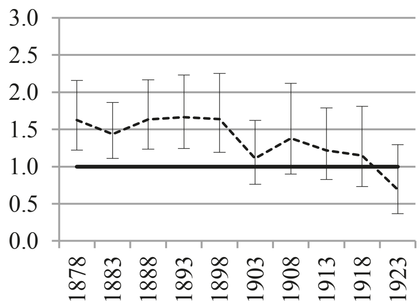
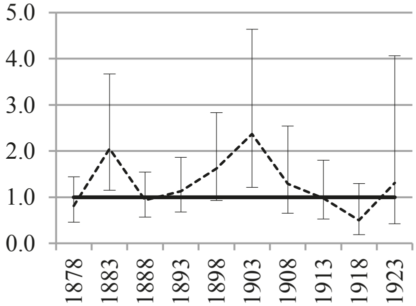


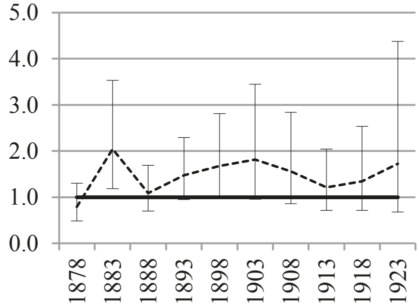
Figure 7 (continued)

IV. Congenital Malformations

(a) Skilled Workers

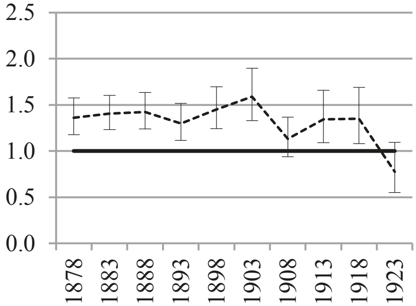


(b) Low and Unskilled Workers

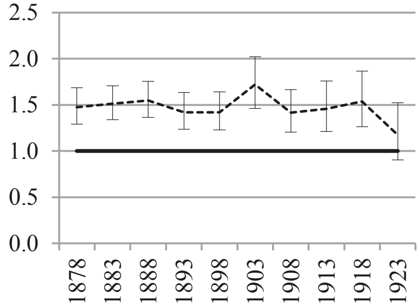


V. Unknown Causes

(a) Skilled Workers



(b) Low and Unskilled Workers



Notes: Figures presented as hazard ratios. The solid line represents the cause-specific hazard of children of white collar workers. 95% confidence intervals are reported.

Source: See Data and Methods sections.

Inequality in mortality from noninfectious diseases also disappeared during the study period. Prior to the twentieth century, both skilled workers and low and unskilled workers alike had about 50% higher risks of mortality from noninfectious illness, but by the end of the nineteenth century this disparity had largely disappeared. The convergence observed here was largely due to declining mortality from accidents and chronic conditions of the circulatory, digestive, and urinary tracts. It is difficult to say for certain why differences in these diseases would be present at all never mind why they would converge. One possibility is that many of these chronic conditions were simply a result of previous exposure to acute bouts of illness from other causes. For example, a large number of deaths in the noninfectious category were due to chronic colitis. Some of these may have been due to earlier acute infections from exposure to unclean food or water while others were likely, in part, due to genetic inheritance (e.g. Crohn's Disease) or other factors. As mortality from food and waterborne illness declined, it may have made some chronic conditions less common as well, leading to smaller differences in mortality from noninfectious disease.

Finally, class differences in mortality from congenital malformations were generally non-existent. The only exception to this was in two sub-periods, 1883-1887 and 1903-1907, both of which saw particularly deadly outbreaks of many infectious diseases, including measles, scarlet fever, pertussis, diphtheria, and tuberculosis, and which may have indirectly affected the incidence of congenital malformations via changes in maternal health. The number of deaths from measles and pertussis, for instance, increased over 200% between 1882 and 1883. In 1886, there was only one recorded death from measles, while in 1887 there were nearly 300. Many of these same diseases also saw resurgence in 1905. Aside from short-term differences, however, inequalities in death from congenital causes were largely absent.

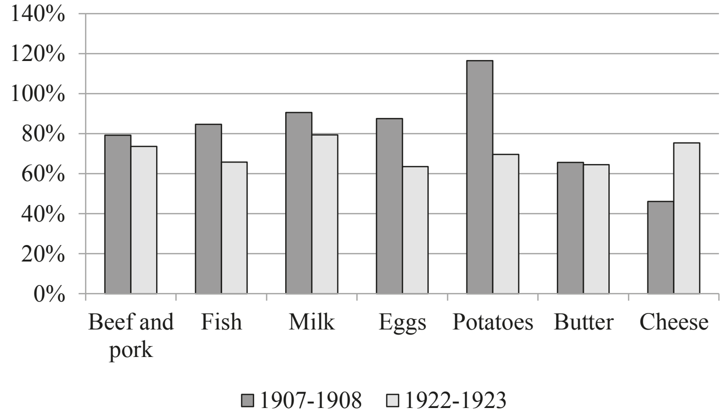
Discussion

This paper has demonstrated that, although overall socioeconomic mortality differentials more or less persisted throughout the bulk of Stockholm's mortality decline, the contribution of specific causes of death to overall differentials changed tremendously. Prior to 1900, class differences in mortality were due to differential exposure to airborne infection, unclean food and water, and chronic illness. But from the end of the first decade of the twentieth century, socioeconomic mortality differentials were almost entirely driven by differences in airborne disease mortality. For all other causes of death, mortality inequality had either disappeared by this point or, in the case of congenital malformations, had not been present to begin with.

The patterns identified here are interesting because they reveal a complex picture of the development of living standards in the past. On the one hand, the changing distribution of child mortality from food and waterborne diseases suggests that investments in public goods, like clean food, water, and sewers, led to equitable mortality outcomes throughout socioeconomic strata. This, in turn, may have also played an important part in reducing some forms of noninfectious chronic illness as well. On the other hand, mortality from airborne diseases, which were by far the most common causes of death, became increasingly identified with the children of the low and unskilled workers. These findings are consistent with the expectations derived from the theory of fundamental causes (Link and Phelan 1995), which argues that causes of death that are less dependent on personal resources should also be less clearly differentiated along class lines.

But the question remains – in what ways did the greater resources of higher status individuals reduce their exposure to airborne diseases and allow them to maintain a health advantage? Of the five proximate determinants of mortality, disproportionate exposure to two was likely responsible for the persistence of mortality differentials after 1900: nutritional deficiency and environmental contamination. Evidence from two cost of living surveys conducted in 1907-1908 and 1922-1923 indicates a widening nutritional gap in the early twentieth century. Figure 8 shows the per capita consumption of low-income households (less than 1300 kronor) as a share of the per capita consumption of middle-income households (more than 2000 kronor). At the start of the twentieth century, low-income households consumed about 20% less meat and other sources of protein. By the early-1920s, however, the gap had widened even further despite overall increases in consumption in all income groups. The growing disparity is especially clear for one of the most commonly purchased sources of protein, eggs. In 1907-1908, higher-income households purchased about 14% more eggs per capita and this gap increased to 37% by 1922-1923. That households with higher levels of income had better nutrition is not surprising, but that this gap increased over time may be an important reason for why airborne mortality differentials failed to disappear.

Figure 8. Per capita consumption in low-income households as a share of per capita consumption in middle-income households for specific items in 1907-1908 and 1922-1923.

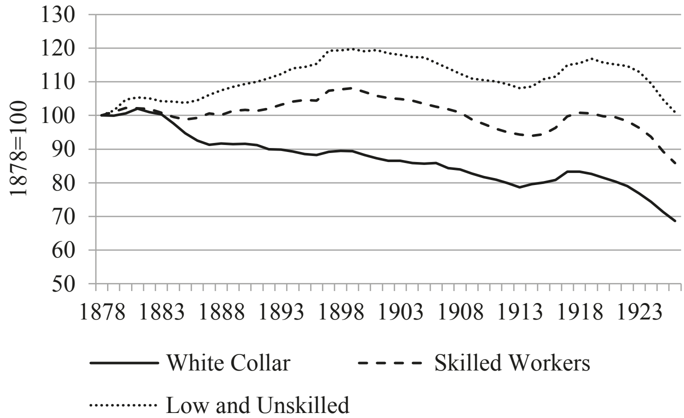


Notes: Low income refers to individuals with an annual salary less than 1,300 kronor and middle income refers to individuals with a salary of more than 1,950 kronor. These categories were provided by the original surveys. A value of 100% signifies that the per capita consumption of a particular good was equal across income groups in the respective survey, while a value of 50% would indicate that low-income households consumed half the amount of a specific good per capita.

Source: For 1907-1908: Stockholms Stads Statistiska Kontor. (1910). *Statistisk Undersökning Angående Lefnadskostnaderna i Stockholm, Åren 1907-1908*. Stockholm: K.L. Beckmans Boktryckeri. For 1922-1923: Stockholms Stads Statistiska Kontor. (1927). *Statistisk Undersökning Angående Levnadskostnaderna i Stockholm 1922/1923*. Stockholm: K.L. Beckmans Boktryckeri.

Another significant factor which may have led to growing differences in airborne disease mortality and, ultimately, persistent differences in overall mortality, was increasingly disproportionate residential crowding among the lower classes. Figure 9 shows the change in mean household size (including servants and lodgers) for the three socioeconomic groups over the period. The figures are presented a ratio of a group's mean family size relative to its size in 1878. Here it becomes obvious that the size of upper class households was shrinking dramatically over the period. By 1926, the average household size had been reduced by over 30%. The skilled worker group also saw reductions in household size, though less dramatic. By the end of observation their households had shrunk by about 15%. The low and unskilled worker group, on the other hand, saw net increases in the number of residents per household for much of the period and, by 1926, the mean household size of this group was roughly the same as it had been nearly half a century prior. These figures have not been adjusted for the physical size of housing structures, but previous work on Stockholm using housing censuses to estimate the number of individuals per square meter has found that the effect of crowding on child mortality was particularly severe among lower social groups (Bernhardt, 1995). It is possible then the growing gap in mortality from airborne disease was partially a result of these trends.

Figure 9. Evolution of mean household size by socioeconomic class.



Notes: Figures represent the difference within socioeconomic groups compared to their mean household size in 1878. Non-family members are included in mean household size (i.e. servants, lodgers).

Source: See Data section.

The results of this paper highlight how, in an unequal society, individual resources can continuously be leveraged to reproduce inequality in the most basic living standards indicators of all, health and survival, even in a context of falling mortality and a changing epidemiological environment. It remains to be seen, however, whether or not the persistent inequality in infant and child mortality observed in Stockholm developed similarly in other urban populations.

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