Urban health inequalities and socioeconomic conditions in Glasgow, Manchester and Nancy, 1850-1950

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Abstract

This thesis examines the impact of socioeconomic conditions on inequalities in mortality, mortality dynamics and health choices in the cities of Glasgow, Manchester and Nancy in the late nineteenth and early twentieth centuries. To undertake this analysis, I created new datasets from historical administrative records. Those for Glasgow and Manchester and their constituent areas were sourced principally from contemporaneous Medical Officer of Health reports. The Nancy dataset consists of individual-level data from death registers and annual censuses, with sampling focusing on the death of the male head of household in the period 1895-1897.

In my first results chapters, Chapters 2 and 3, I focus on mortality differentials between small areas of Glasgow and Manchester. In Chapter 2, I use descriptive and regression analysis to show that inequalities in mortality are closely associated with initial socioeconomic conditions, with this influence lasting for forty years or more. Chapter 3 focuses on the dynamics of mortality reductions, and I find that reductions follow sigmoid dynamics, with higher socioeconomic areas benefitting earlier from mortality gains. In Chapter 4, I examine vaccination decisions in early twentieth century Glasgow and find a persistent association between high levels of vaccine refusal and lower socioeconomic conditions. In Chapters 5 and 6, I study families who suffered the loss of the male head of household in Nancy in the 1890s. In Chapter 5, I find that occupation had an influence on age at death, but that for these prime age individuals, most of the variation in age at death was driven by random factors. In Chapter 6, I use regression analysis and find that, following the death of the head of household, the accommodation position of the families became less stable, but that socioeconomic conditions did not play a significant role.

Taken together, my findings indicate a clear and long-lasting association between socioeconomic conditions and mortality outcomes and health decisions in three large cities in northern Europe during the late nineteenth and early twentieth centuries. Focussing on the period which saw the first sustained falls in mortality rates, my findings add to the considerable literature on socioeconomic influences on health inequalities.

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Author's declaration

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

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Chapter 1 Introduction

Historical health inequalities are known to have existed between different countries such as the United Kingdom and Spain in the nineteenth century and Sweden and Japan in the early twentieth century (Santosa et al., 2014), between rural and urban areas, and between different cultural groups. In part due to a lack of reliable data, there is little clear evidence that historical inequalities were consistently related to the socioeconomic status of individuals, although data from the sixteenth and seventeenth centuries for London and Geneva suggest that wealthier areas had lower death rates (Cummins et al., 2016, Mackenbach, 1995). From 1750 onwards, there is clearer evidence that socioeconomic conditions played an important role in mortality (e.g. Antonovsky, 1967, Woods and Williams, 1995, Reid, 2021). My work focuses on health inequalities within three urban areas from 1850-1950, using newly created datasets drawn from historical administrative records. The source data are publicly available, either on-line or in municipal archives, but have not previously been transcribed into a digitised format which permits detailed study. I am able to show, via a variety of statistical and graphical analyses, that socioeconomic conditions had a significant and persistent association with health inequalities during the period studied.

The period I study corresponds to the time of significant falls in mortality that were first seen in north-west Europe and northern America. I focus on three cities that were growing rapidly during this period and for which good archival data are available. Glasgow and Manchester grew from being relatively small towns in the early nineteenth century to become two of the largest cities in the United Kingdom outside London by 1900. Glasgow is an example of a city that saw severe health inequalities in the past (e.g. Gairdner, 1864, Russell, 1888) and which still experiences significant health inequalities (e.g. Conway et al., 2019, Gray and Leyland, 2009, McCartney, 2011, Walsh et al., 2016). Manchester is an industrial city which saw similar growth and health inequalities to Glasgow, and with which it is often compared (e.g. Taulbut et al., 2016, Walsh et al., 2010). Nancy, in north-east France, experienced a smaller but still significant enlargement from being the main town of a *département* (county) in the 1860s to becoming the administrative capital of north-east France in the 1890s. The

causes of immigration into Nancy were different to those of the two British cities, in that they were strongly influenced by the movement of populations that resulted from the Franco-Prussian War of 1870 (Sicard-Lenattier, 2002). Nevertheless, although for different reasons, the town expanded to become a significant industrial centre in the late nineteenth century. Using archival data from the late nineteenth and early twentieth centuries from the three cities, I consider the impact of socioeconomic conditions on health inequalities, examining mortality, mortality dynamics, health behaviour and how families react to severe health crises.

In order to undertake this work, I first constructed three unique new datasets. The datasets for Glasgow and Manchester were sourced principally from contemporaneous Medical Officer of Health reports, with additional data taken from Registrar-General reports and the decennial censuses. Data at the city level cover 1837-1955. The key component of these datasets is the collection of data by small geographic areas of both cities, 1878-1937 for Glasgow and 1891-1924 for Manchester. These data are used to analyse the differing impact of socioeconomic conditions across these small areas of the two cities. The Nancy dataset follows a different approach, consisting of individual level data sourced from death registers and annual censuses. The focal point for this dataset was the death of the breadwinner of a household in the period 1895-1897. The existence of unusual, and very detailed, annual censuses for the city of Nancy enabled the collection of data on these deceased heads of households, other family members and many socioeconomic and other variables. Working with this new dataset, I was able to examine the impact of socioeconomic conditions on age at death of the breadwinner and the situation of the family left behind in the years immediately following bereavement, which has not been possible for researchers using quinquennial or decennial censuses.

The creation of these unique datasets provided the opportunity for undertaking new analyses of this key historical period when the countries of north-western Europe were experiencing a sustained fall in mortality. The datasets include a variety of socioeconomic measures, meaning I am able to examine their different influences. The datasets for Glasgow and Manchester focus on small geographic areas within the cities. The measures used here include: persons per

acre, indicating population density; and persons per room, a measure or overcrowding but also of income. Illegitimate births as a percent of all births is used as an indicator of socioeconomic conditions which probably reflects values and attitudes rather than the availability of resources (see e.g. Ventura, 1969). The proportion of the population born in Ireland is also included in some analyses to recognise a possibly different cultural heritage. Not all measures are available for both cities or all time periods. For Nancy, I have created a household panel dataset which includes such socioeconomic measures as occupation, income (proxied by rent) and persons per room. Due to the level of detail of the Nancy censuses I am also able to consider such characteristics as household size, number of children living at home and the neighbourhood of Nancy in which the family lived. The existence of multiple measures enables me once again to separate out the individual influence of the different measures, for example considering both income and occupation, which are rarely found together in historical datasets.

Chapter 2 of my thesis explores socioeconomic conditions and mortality inequalities during the mortality transition in the cities of Glasgow and Manchester. The mortality transition describes the significant and sustained decline in the death rate first seen in the early industrialised economies during the second half of the 19th century and the early decades of the 20th century, so that death rates fell from sustained high levels of over 30 per thousand population to around one third of that level (Dyson, 2010, Mitchell, 2003). Although the fall in mortality rates was experienced by all groups in society, there were persistent inequalities between different groups and areas throughout the period (e.g Bengtsson and Van Poppel, 2011, Bonnet and d'Albis, 2020, Lindert, 2000, Mackenbach, 2006). In this chapter, I first describe how I created the datasets that allowed me to analyse the mortality transition in Glasgow and Manchester. I then examine mortality differentials among the small geographic areas of the cities, considering how these were associated with socioeconomic conditions. My results demonstrate that variation in mortality rates within the two cities was strongly associated with initial socioeconomic conditions, with lower socioeconomic conditions being linked with higher mortality. My approach allows me to show that this link is remarkably persistent, with initial socioeconomic circumstances in an area being associated with

mortality in that area forty or more years later. In Glasgow, a high number of persons per room is associated with higher average mortality over the whole period, but has no significant association with end of period mortality, suggesting that policy measures aimed at reducing overcrowding in the most deprived areas of the city may have been successful by the end of the period studied. In both cities, the influence of population density, which may indicate the level of access to outdoor open space and also represent levels of pollution, was long-lasting, as were the circumstances represented by the percent of illegitimate births. Even by the end of the period studied, there remained significant mortality inequalities between areas of both cities, linked to initial socioeconomic conditions.

In Chapter 3 I use the long time series of death rates for Glasgow and Manchester, starting in the middle of the 19th century, and for their small constituent areas, starting in the 1870s and 1890s respectively, to analyse the dynamics of mortality reductions. I find that mortality reductions follow sigmoid dynamics, with an initial period of slow reductions before faster reductions that start from around 1880 at the city level, associated with an inflection point of trend mortality at around 1900; the inflection point is the point of the most rapid reductions in mortality. The timing of the period of fast reductions varied markedly between small areas of the cities and depended on the initial socioeconomic conditions. In particular, mortality fell earlier in areas with, on average, higher socioeconomic conditions, which meant that these areas increased their mortality advantage over lower socioeconomic areas. Once the high mortality areas began to enter the mortality transition themselves, this gap reduced. My results show that the mortality transition saw a period of increasing mortality inequalities between small areas of the two cities, rather than seeing a monotonic convergence of mortality levels, with these mortality inequalities linked to unequal social conditions. These new findings contribute to an understanding of historical mortality divergence and convergence, where there is currently no clear consensus. Mortality inequalities in the two cities only appear to have reduced from around the time of the First World War. At the beginning of the period studied, some areas of the cities were more than three generations ahead of other areas in terms of mortality; by the end of the period this had fallen to two generations, but the gap remained stark.

In Chapter 4 I study the importance of socioeconomic conditions for health-related choices, in this case for vaccination decisions. In the early twentieth century, parents in Scotland were able to make far fewer choices regarding the health of their children than became available to them subsequently. The serious diseases of childhood were largely infectious, and how much a family suffered was closely related to income, with childhood mortality far higher among the poor (e.g. Preston and Haines, 1991). One of the few decisions over which parents did have agency was regarding the vaccination of their children against smallpox, once vaccine refusal became legal in Scotland in 1907. Here I study the socioeconomic influences on vaccination refusal in order to highlight their impact on health choices. My analysis uses administrative records of parental refusal to vaccinate their infants (called "conscientious objection to vaccination") for Glasgow from 1907 until prior to the First World War, to determine whether there is any association between socioeconomic conditions and the choices made. I find that during this period, socioeconomic conditions have a strong association with decisions about vaccination, with lower socioeconomic areas, as indicated by higher persons per room, having higher rates of vaccine refusal. I repeat the analysis for a period following the First World War and find that the influence of socioeconomic conditions continues to exist. My work contributes a quantitative analysis of historical vaccination decisions, which I have not seen undertaken before, and I show that the influence of the specific social factors represented by person per room, an indicator of income, appears to have strengthened over time. The association between high levels of vaccine hesitancy and lower socioeconomic conditions is also seen in current times (e.g. Bocquier et al., 2017, Kohlhammer et al., 2007), which may indicate the presence of deep-seated social structures that have not altered much over time.

In the next two chapters of this thesis, I focus on the city of Nancy, and in particular on a sample of families who suffered bereavement in the period 1895-97. The occupation of the head of household, a marker of socioeconomic conditions, has been used in many studies to explain variations in mortality in the nineteenth century. Higher occupational status is generally associated with lower mortality (e.g. Jaadla et al., 2020, Preston and Haines, 1991, Woods and Hinde, 1987), but it has rarely been possible to partial out other influences such

as income or housing conditions, which I am able to do. Most research to date focusses not on the mortality of adults but on that of children, usually under the age of five, because this group suffered the highest mortality rates (e.g. Cage and Foster, 2002, Woods and Hinde, 1987). In Chapter 5, I use the unique dataset I created to examine the death of the breadwinner in Nancy in the 1890s to study influences on the age at death in a sample of adult men. I am able to consider occupational status net of other socioeconomic variables. Within this sample, there is a clear and consistent association between lower occupational status and death at a younger age, over and above the influence of other factors. Income - as proxied by rent - itself is a less powerful explanatory variable than occupational status, suggesting that, in my sample, it was not so much the poor who died younger, but those in lower status occupations.

The death of the head of household in the nineteenth century had a major impact on the family left behind, and in Chapter 6 I examine this impact for my sample of families in Nancy in the period immediately following bereavement. Most literature suggests that the impact of losing the breadwinner would be negative, with higher subsequent mortality and poorer long-term outcomes compared with families where both parents survived (e.g. Debiasi et al., 2021, Derosas, 2002). Socioeconomic conditions and area effects have also been shown to impact on the outcomes for bereaved families, with families with lower socioeconomic conditions and in urban areas generally faring worse (e.g. Beekink et al., 2002, Farron and Renard, 2002, Wall, 2002). My research focuses on how families adjusted financially following bereavement, using the rent paid for accommodation as a marker of the families' financial position. Analysis of this period immediately post-bereavement has not been possible for other researchers due to the length of time between most censuses, which are quinquennial or decennial. Bereaved families appear to have a less stable accommodation situation than prior to the death of the breadwinner and to pay, on average, a lower rent. However, the fall is relatively small, with rents falling by around 10% three years after the death of the breadwinner. The findings on the impact of socioeconomic conditions on how the bereaved family coped subsequently are mixed, with markers such as high persons per room and low occupational status of the breadwinner not being strongly associated with moves to cheaper accommodation. There appears to be some impact from the area in

which the family lived, with families residing in the better areas of the city more likely to maintain or even improve their accommodation situation. This suggests that socioeconomic conditions may be acting via the neighbourhood rather than by a family's individual socioeconomic status.

Due to the detailed nature of the Nancy dataset, I am also able to examine other impacts on the family following the death of the breadwinner. I consider, among other things, the subsequent mortality of other family members and whether widows remarry. Although the numbers available are too small to permit statistical analysis, there appear to be links between lower socioeconomic status and higher family mortality. The likelihood of the widow remarrying, on the other hand, appears to be most closely related to the number of children, with widows with no or few children most likely to remarry.

The creation of these unique datasets has allowed me to study socioeconomic influences on health inequalities in the late nineteenth and early twentieth centuries in three European cities. Analysis of the association between mortality, health choices and socioeconomic conditions shows that the impact of socioeconomic conditions was significant and persistent. My examination of the cities of Glasgow and Manchester during the mortality transition suggests that some policies, such as those introduced to reduce overcrowding in Glasgow, may have had a long-term positive impact on mortality, but little appears to have been done in either city to address issues of population density, at least in the period studied. My analysis reveals the influence of socioeconomic conditions on the age at death of the men in my Nancy sample, with higher occupational status being associated with death at an older age, over and above the impact of other socioeconomic conditions. The impact of socioeconomic conditions on how the family coped following bereavement is less clear, and this is an area that would benefit from further study.

Understanding the health and mortality risks of previous populations is key to understanding health and mortality risks today, for example by suggesting which associations are more or less amenable to policy interventions. My research supports an understanding of the interaction of different factors such as occupation, income and geographical location on historical inequalities in health

and mortality. Focussing on the period in history which saw the first sustained falls in mortality rates, my findings add to the considerable literature on socioeconomic influences on health inequalities.

The thesis includes appendices containing additional information and alternative regression analyses for robustness checks. These are placed at the end of the thesis, with a separate appendix for each of the main chapters. A glossary is provided after the appendices, providing an explanation of various terms used.

Chapter 2 Socioeconomic conditions and persistent mortality inequalities during the mortality transition: evidence from small areas of Glasgow and Manchester

2.1 Introduction

Mortality rates in parts of Europe and North America saw a rapid decline in the nineteenth century and in other parts of the world thereafter. Prior to 1750, the death rate in northern Europe averaged between 30 and 40 per thousand population, with no specific trend (Dyson, 2010). Death rates began to fall in the second half of the eighteenth century, but the high mortality rates seen in urban areas slowed or even reversed this trend from around 1820. In the middle of the nineteenth century, death rates were around 25-30 per thousand (Dyson, 2010, Mitchell, 2003). Mortality rates only began a sustained fall from around 1870 such that by around 1950, the average death rate in northern Europe had fallen to 10-12 per thousand population (Mitchell, 2003), or around one third of its level a century earlier. This secular decline in mortality rates during this period is often referred to as the 'mortality transition'. My data on Glasgow and Manchester, two of the largest UK cities outside London around 1900, confirm high initial death rates followed by a sustained fall, with death rate per thousand population averaging around 35 in the 1840s and falling to around 12 in both cities by the 1950s.

Prior to 1750 there is some evidence that socioeconomic conditions contributed to mortality inequalities, for example wealthier parishes in London benefitted from lower death rates from around 1560 (Cummins et al., 2016) and richer families had a significantly longer life expectancy than poorer ones in Geneva in the 1600s (Mackenbach, 1995, Perrenoud, 1975). There were also disparities between different groups, separated by culture or location, in addition to those between the rich and the poor (Bengtsson and Van Poppel, 2011, Woods and Williams, 1995). Widespread evidence of a consistent mortality gradient dependent on socioeconomic conditions is found following industrialisation, when areas where residents had higher income or social class demonstrated lower mortality rates (e.g. Antonovsky, 1967, Blum et al., 1990, Kesztenbaum

and Rosenthal, 2016, Kesztenbaum and Rosenthal, 2017, Woods and Williams, 1995, Davey Smith et al., 2001). Even at the beginning of the twenty-first century, mortality remained higher in areas with lower socioeconomic conditions than in ones with higher socioeconomic conditions (e.g. Di Girolamo et al., 2020, Keenan et al., 2022).

My research uses new datasets that I have created for small areas of Glasgow from 1878 to 1937 and of Manchester from 1891 to 1924, based largely on the contemporaneous reports of the Medical Officers of Health. To my knowledge, no researchers have previously systematically transcribed these data into a digitised format, creating shareable datasets of mortality and other variables. My aim is to assess the persistence of the influence of socioeconomic conditions on mortality differentials among these small areas of Glasgow and Manchester.

I construct datasets on measures of mortality and socioeconomic variables sourced principally from the Medical Officer of Health reports for Glasgow and Manchester. I use a least squares statistical model to examine the relationship between two alternative measures of mortality and variables representing socioeconomic conditions. Three socioeconomic variables are available for Glasgow: persons per room, population density and the percent of births that were illegitimate. The latter two variables are also available for Manchester. These variables allow me to examine whether different aspects of socioeconomic conditions have different influences on mortality.

In Glasgow, the mortality penalty, a variable I create to measure excess mortality, is positively associated with all three variables jointly, suggesting that overcrowding within the home, lack of space/clean air outside the home, and the conditions that percent of illegitimate births is representing all influenced the whole-period mortality position. A high number of persons per room in 1891 does not, however, appear to influence end-of-period mortality, with the main variables associated with this being population density and the percent illegitimate births, i.e. the environment outside the home, and social attitudes or other aspects which may be indicated by the percent of illegitimate births. Results for Manchester show that both population density and the percent of illegitimate births were associated with long-term mortality differentials.

My results first confirm that socioeconomic conditions were closely associated with mortality, with lower socioeconomic districts have higher death rates over the period being studied. Second, they clarify that initial socioeconomic conditions had a persistent effect of mortality rates, showing that even by the end of the period, 1937 for Glasgow and 1924 for Manchester, the influence of initial socioeconomic conditions on mortality levels continued to exist.

The remainder of this chapter is structured as follows: Section 2.2 is a review of relevant recent literature and 2.3 gives a brief historical background for both Glasgow and Manchester. Section 2.4 discusses the data that were collected to create the datasets for the cities. Section 2.5 analyses the association of socioeconomic conditions at the start of the period with two measures of mortality. Section 2.6 discusses my findings.

2.2 Literature review: mortality inequalities and socioeconomic conditions

Mortality inequalities have been widely studied, both historically and in current times, and are generally considered to be unfair and, in many circumstances, avoidable (e.g. Marmot, 2020, McCartney et al., 2019). I review how historical mortality differentials have been linked to socioeconomic factors, including income, occupation, education level, overcrowding and the environment close to the home, in addition to cultural differences. Many early attempts to lower mortality levels were public health measures taken at a whole city level, for example the introduction of piped clean water and connections to sewage systems, but even these have been shown to have differential impacts depending on a household's socioeconomic circumstances.

Prior to 1750, the crude death rate in western Europe was high, averaging over 30 per thousand population, with wide fluctuations so that in some years the death rate was over 50. Although socioeconomic conditions are now considered to be closely linked to health, prior to 1750 there is a lack of large-scale data on mortality and socioeconomic conditions, although there are indications that wealthier parishes in London benefitted from lower death rates from around 1560 (Cummins et al., 2016) and richer families had a significantly longer life

expectancy than poorer ones in Geneva in the 1600s (Machenbach 1995, Perrenoud 1975). Robb et al also suggest that socioeconomic conditions had a contributory role to variations in mortality in medieval times (Robb et al., 2021). Other research has indicated that, in the seventeenth century, ducal families in England had similar or even slightly higher death rates than the population average, despite their access to higher levels of resources, perhaps because poor hygiene and exposure to virulent diseases were the same for all (Harris, 2004), or due to the practice of wet nursing that was common among the better off (Kendall et al., 2021). High mortality from plague outbreaks in the sixteenth and seventeenth centuries were experienced by all levels of society (Kelly and Ó Gráda, 2014). Additionally, there is evidence to suggests the existence of disparities between groups with differing cultural or religious norms, rather than specifically between the rich and the poor (Bengtsson and Van Poppel, 2011, Woods and Williams, 1995).

The first evidence of a clear and consistent mortality gradient dependent on socioeconomic conditions is seen early in the period of industrialisation. During this period, more wealthy sections of the population were able to use their additional resources to live in less crowded areas, gain earlier access to clean water and sanitation (Kesztenbaum and Rosenthal, 2017, Kesztenbaum and Rosenthal, 2016) and benefit from improved nutrition (Floud et al., 2011). Higher socioeconomic conditions may also have provided the opportunity to obtain information on causes of ill health and the importance of good hygiene, adding still further to the socioeconomic health gradient (Floud et al., 2011, Kesztenbaum and Rosenthal, 2016). Higher education levels, closely associated with higher income, also provided better off households with the ability to understand the new information on the causes of ill-health that was becoming available (Skare and Soriano, 2021).

From the middle of the nineteenth century, and certainly from 1870, mortality rates began a sustained decline; however, socioeconomic conditions continued to influence mortality. For example, although public health measures were usually introduced at a city level, and therefore should have benefitted all inhabitants, their impact was often contingent on socioeconomic status. Municipal authorities might lay sewers up to all buildings, but internal

connections initially remained the responsibility of the landlords, with those in poorer areas less willing to incur these additional costs (Kesztenbaum and Rosenthal, 2017). Focussing on infant mortality, researchers have found higher mortality linked to larger family size and more overcrowded accommodation, the latter being associated with a lower income (Cage and Foster, 2002). Regional variations in early childhood mortality in England and Wales have been found to be related to the disease environment and population density, but less to social class directly (Jaadla and Reid, 2017). Higher mortality levels have been linked to living in a more polluted environment, in unventilated houses and with less access to space for outdoor recreation (Braveman and Gottlieb, 2014, Rojas-Rueda et al., 2019, Russell, 1887, Russell, 1888). Although these factors are not necessarily linked to socioeconomic conditions, in urban areas there was often a close association between an unhealthy environment and lower socioeconomic conditions, because of the role of income in allowing families to access additional space and to avoid polluted environments (e.g. Garrett and Reid, 1995, Mackenbach, 2006, Reid, 1997).

Socioeconomic conditions have been shown to have a long-lasting impact on health and mortality. The relationship between socioeconomic conditions in late nineteenth century London to health in the same areas 95 years later has been demonstrated (Dorling et al., 2003), with similar conclusions being reached regarding mortality. It is suggested that, for some causes of death, prior socioeconomic conditions are more strongly associated with mortality than contemporaneous conditions (Orford et al., 2002). There is also evidence that less measurable aspects of the socioeconomic gradient, such as inequitable access to power, work and other opportunities, also lead to health and mortality inequalities, as do variations in social norms and values (Braveman, 2023, Marmot, 2020, Marmot and Wilkinson, 2006).

Despite the clear importance of the socioeconomic gradient in mortality post-1750, other factors continued to play a part, sometimes in conjunction with socioeconomic variation. Urban areas saw higher levels of mortality, at least up to the early twentieth century, with higher population density leading to increased deaths from communicable diseases that impacted particularly on infant mortality and early childhood mortality (e.g. Congdon et al., 2001,

Haines, 2011). Higher mortality has been associated with certain industries, for example in areas where the dominant industry was textiles or mining (Jaadla and Reid, 2017). Cultural and religious differences have also been found to impact on mortality levels, regardless of income or occupational differences (Thornton and Olson, 2011), with cultural differences in the feeding and care of infants being especially significant (Derosas, 2003).

The fall from a sustained high death rate to a sustained low death rate has been linked to modern economic development, via impacts on fertility, education and technological progress (Dyson, 2010, Galor, 2005, Galor, 2011, Kalemli-Ozcan et al., 2000, Murtin, 2013). The fall in the mortality rate should therefore not be considered only as an advance in its own right, but as crucial for the increased standard of living seen by most of the world's population over the last two centuries. The persistence of mortality inequalities has important implications for access to the benefits that flow from lower mortality rates.

2.3 Historical background

2.3.1 Glasgow

Glasgow grew from a town with a population of around 24,000 in 1750, less than half that of Scotland's capital city, Edinburgh, to become the second largest city of the United Kingdom with a population of over one million in 1910, see Figure 2-1. As the size of the population grew the area of the city was extended. The historic 'old town' had grown up around the cathedral, High Street and Glasgow Cross area. By the early 1800s new residential building had been carried out to the west of this creating a 'new town' in what became Exchange and Blythswood (Figure 2-2). There was relatively little purely industrial development at this stage, what industry there was being mostly mixed with residential areas situated in the east end (e.g. Calton and Mile End), along the banks of the Clyde (Broomielaw), with only small areas in the west (Anderston) and north (Port Dundas and St Rollox).

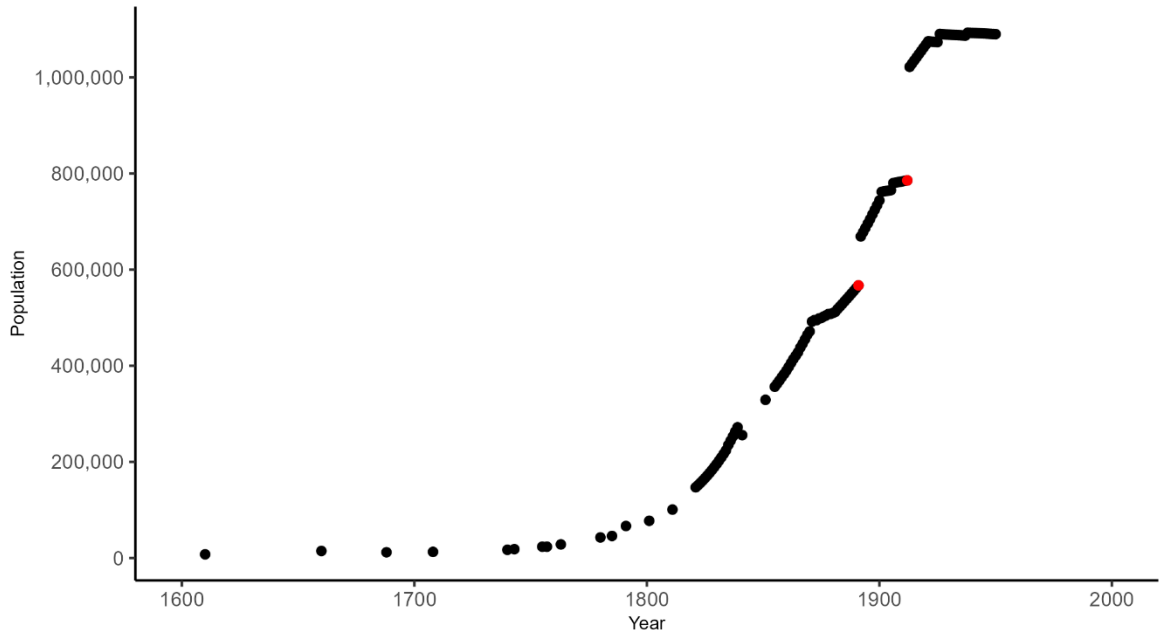


Figure 2-1. Population of Glasgow, 1600-1950.
Red dots mark a major extension of the city boundaries. Data sources are Glasgow Enumeration Reports, Glasgow Vital Statistics Reports and Glasgow Medical Officer of Health Reports. Full details are provided at 10.5281/zenodo.10817542.

Within fifty years, new middle class residential areas had extended even further west and south, beyond the boundaries of what was then the city of Glasgow (Fraser and Maver, 1996). The wealthier households who had moved to Exchange and Blythswood started to move into these areas, and these two central districts became predominantly commercial. The industrial areas in the east and north also enlarged (Pacione, 2015).

The city's administrative boundaries were extended repeatedly, the most significant increase taking place in 1891 (Chalmers, 1898), when the area controlled by the Corporation of Glasgow went from 6,111 acres to 12,311 acres (Figure 2-3). The new areas to the south, which were to become Pollokshields and Langside wards, were predominantly middle-class, as was Kelvinside (to the west and south of the river Kelvin). The other major additions were Maryhill, a lower middle-class residential area to the north and east of the river Kelvin, and Possilpark and Barnhill, a lightly populated mixed residential and industrial area to the north of the city. It can be seen in Figure 2-3 that there is an area shaded white to the west and south of 'K&S' that might be expected to have also been incorporated into the city at this point. This comprised the independent burghs of Partick (north of the Clyde) and Govan (south of the Clyde), which had long

opposed annexation by Glasgow. These areas did eventually become part of the city at the next significant enlargement in 1912 (Chalmers, 1912a).

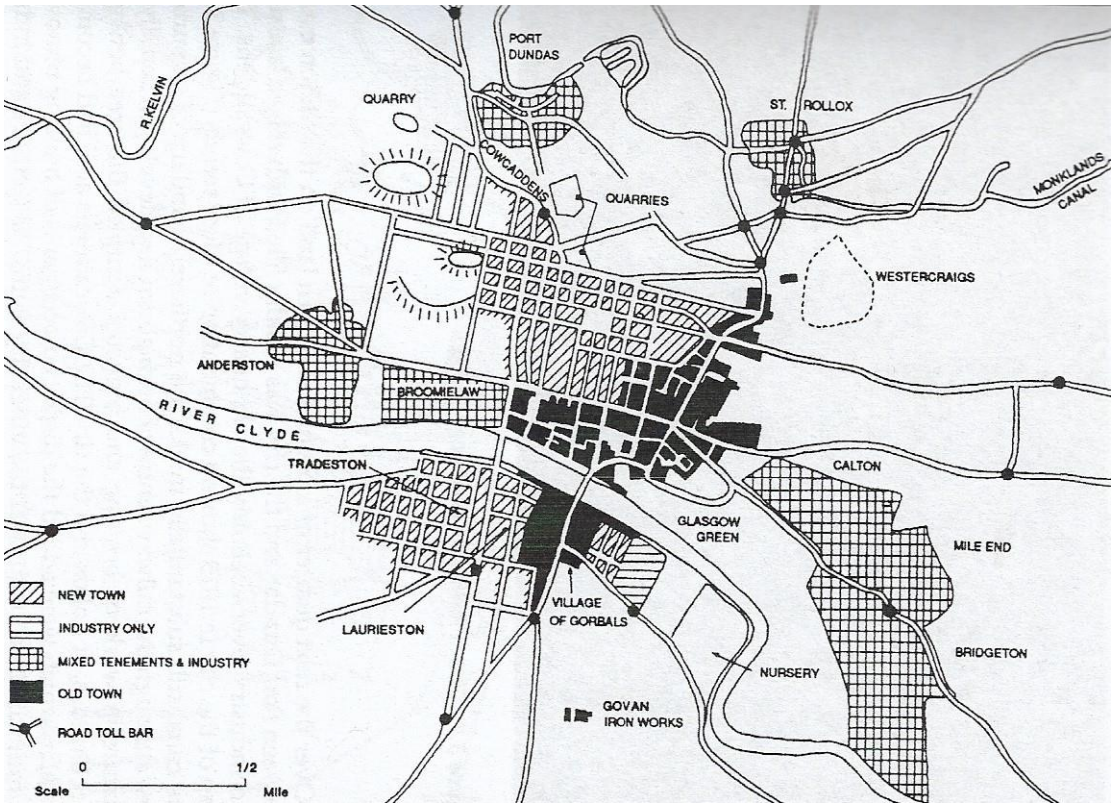


Figure 2-2. Simplified map of land use in Glasgow, 1825
(Pacione, 2015, p69 © 1995. Reproduced with permission of The Licensor through PLSclear).

During the nineteenth century, the city experienced numerous health problems associated with its rapid growth, which resulted from challenges in housing, sanitation and infrastructure (Cage, 1983). Overcrowding and the resultant health impacts were not felt equally by all parts of the city; average persons per acre, indicating population density, peaked at 93 in 1891 (Chalmers, 1902b) but was as high as 499 per acre in the Brownfield sanitary district in 1878 (marked 'Br' in Figure 2-3) (Russell, 1886). In 1903 the 33 sanitary districts were reorganised into 25 municipal wards (Figure 2-4).

The new wards were generally larger and population density was not so high as with sanitary districts, but it nevertheless varied from 13 persons per acre (Pollokshields, ward 23) to 231 persons per acre (Cowcaddens, ward 16) (Chalmers, 1903). Glasgow also suffered from severe air pollution such that the Medical Officer of Health labelled it a 'semi-asphyxiated city' (Russell et al.,

1905, p141). Pollution came both from the factories and from the houses themselves, where heating and cooking was undertaken using coal, the replacement of which with smokeless fuels was not imposed until the Clean Air Act of 1956 (1956).

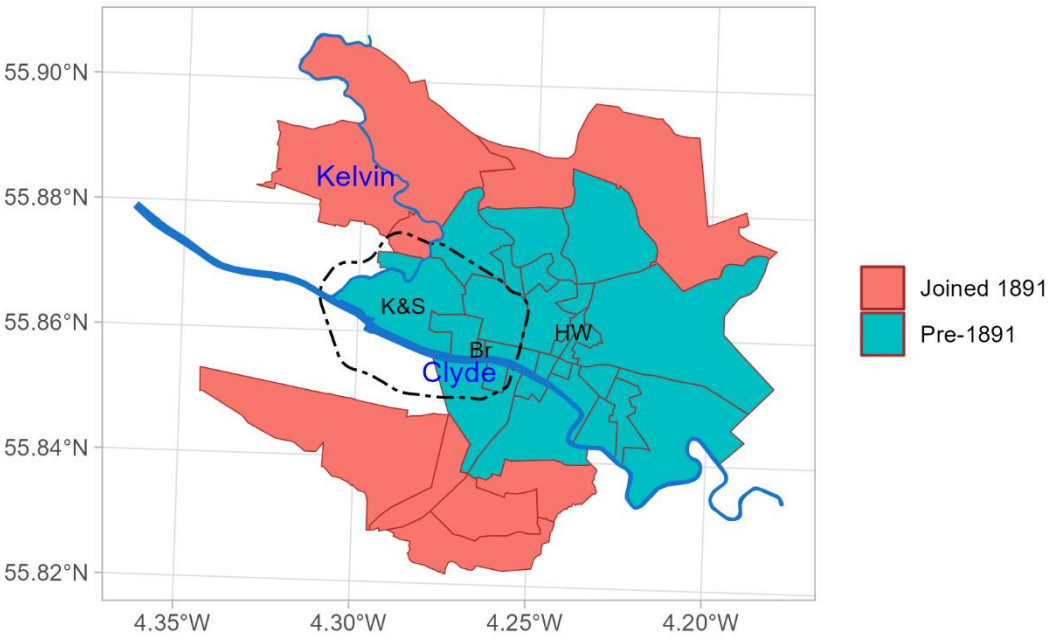


Figure 2-3. Areas of Glasgow in 1891, following a significant enlargement
New areas are shown in red. The administrative areas in use at this time were sanitary districts and their outlines are shown by grey lines. The outline of the subway is shown as a dashed black line and the rivers Clyde and Kelvin are shown in blue. Areas referred to in the main text are indicated: Brownfield is marked Br, High Street and Closes West HW and Kelvinhaugh and Sandyford K&S. (Map based on Mancy, 2020b, Mancy, 2020a, Mancy, 2020c).

The Medical Officer of Health Report for 1903 contained a map showing both sanitary districts (from prior to 1903) and municipal wards (1903 onwards), making it possible to see the relationship of these two sets of boundaries. The map is not easy to read at a small scale but is included in the appendices for information (Figure 8-1).

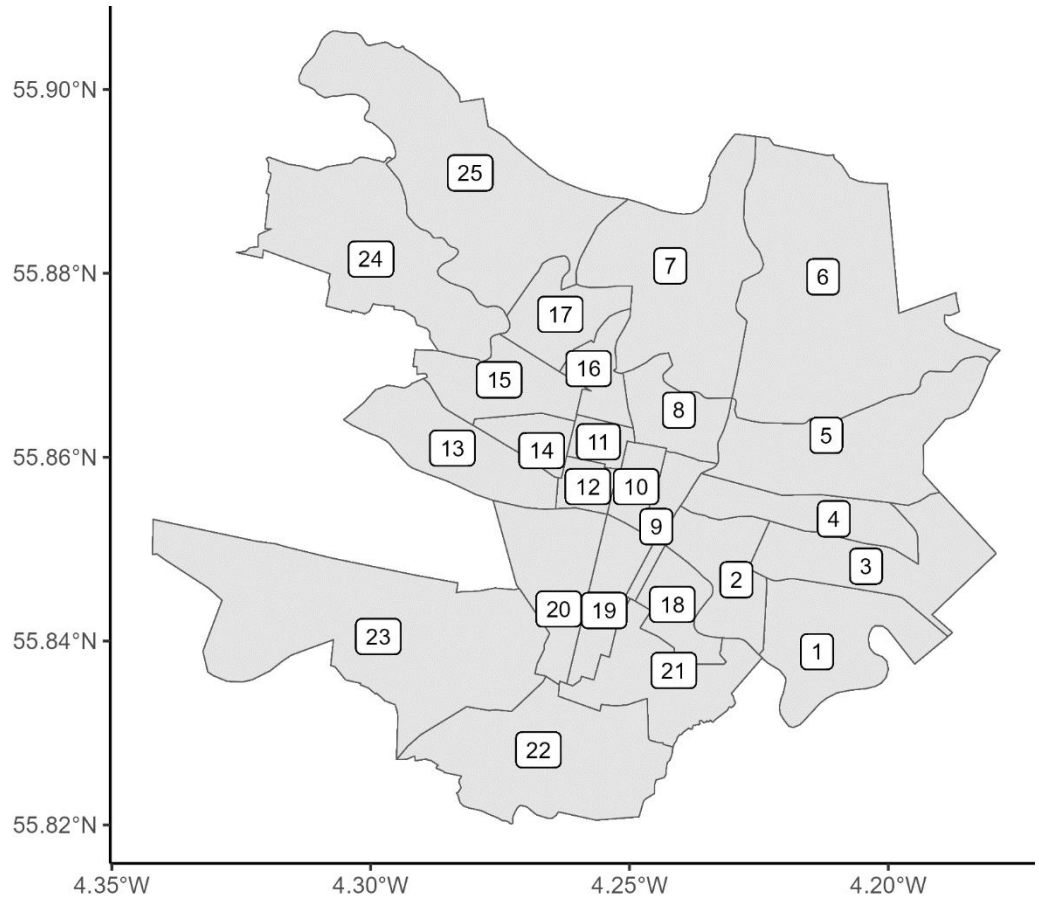


Figure 2-4. Map of the 25 Glasgow wards that were created in 1903 (Mancy, 2020d)
See Appendix 8.1.1, Table 8-1 for ward names.

In terms of mortality, the average observed death rate in Glasgow peaked at 39.9 per thousand population in 1845-49, having increased from an average of around 26 per thousand in the early nineteenth century (Flinn, 1977). Data for individual areas within the city are only available from 1871, but in that year the death rate was 52 per thousand in High Street and Closes West (General Register Office, 1872), marked 'HW' on Figure 2-3, meaning that more than one in twenty of the population of the area died in that year. By comparison, the city average death rate at the time was 32 (Chalmers, 1902b), the Scottish average was 22 (Mitchell, 2003), and the best of any district of Glasgow was Kelvinhaugh and Sandyford with a death rate of 20 (K&S on Figure 2-3).

2.3.2 Manchester

Like Glasgow, Manchester grew to become a large city over a relatively short period of time. In 1800, the population was around 60,000 but by 1831 this had more than doubled to 164,000 and by 1924 was over 750,000. This increase in

population meant that the city grew from one with little endemic infectious disease in the early nineteenth century to one where major killers such as measles and scarlet fever were endemic by the middle of the century (Davenport, 2015), with death rates being particularly high in the 1830s-40s. As the population increased, the city expanded from its original core of Central, St George's and Ancoats districts into the adjoining northern, eastern and southern areas; Figure 2-5 shows the city as it was in 1891. In 1905 Moss Side and Withington statistical divisions were added to the south of the existing area and in 1910 Gorton and Levenshulme were added to the south-east. All four of these divisions were relatively affluent compared to the existing city, with persons per acre and death rates lower than the city average. Around this time the land use in Chorlton-upon-Medlock also changed from being predominantly residential to becoming a mixture of working-class residential and commercial properties (Banens, 2021).

To the west, Manchester bordered the neighbouring city of Salford, which was situated on the opposite bank of the river Irwell and prevented expansion in that direction. Although geographically adjacent, Salford was an independent administrative district, with a population of 52,000 in 1831, rising to 244,000 in 1924. Data for Salford were collected separately from data for Manchester, and the city of Salford was divided into four relatively large districts until 1907, whereafter it was arranged into 16 wards. Because of the proximity of the two, Manchester and Salford are sometimes studied as a single 'city' (e.g. Hewitt, 2016). However, it is not feasible to treat them as a single entity when studying small area differentials, due to the fact that the Salford data series is interrupted in 1906, and to the large size of Salford districts – the average population of the districts was 50,000 in 1891 compared to Manchester statistical divisions which averaged 28,000 – which meant there was relatively little variation between them with regard to socioeconomic conditions.

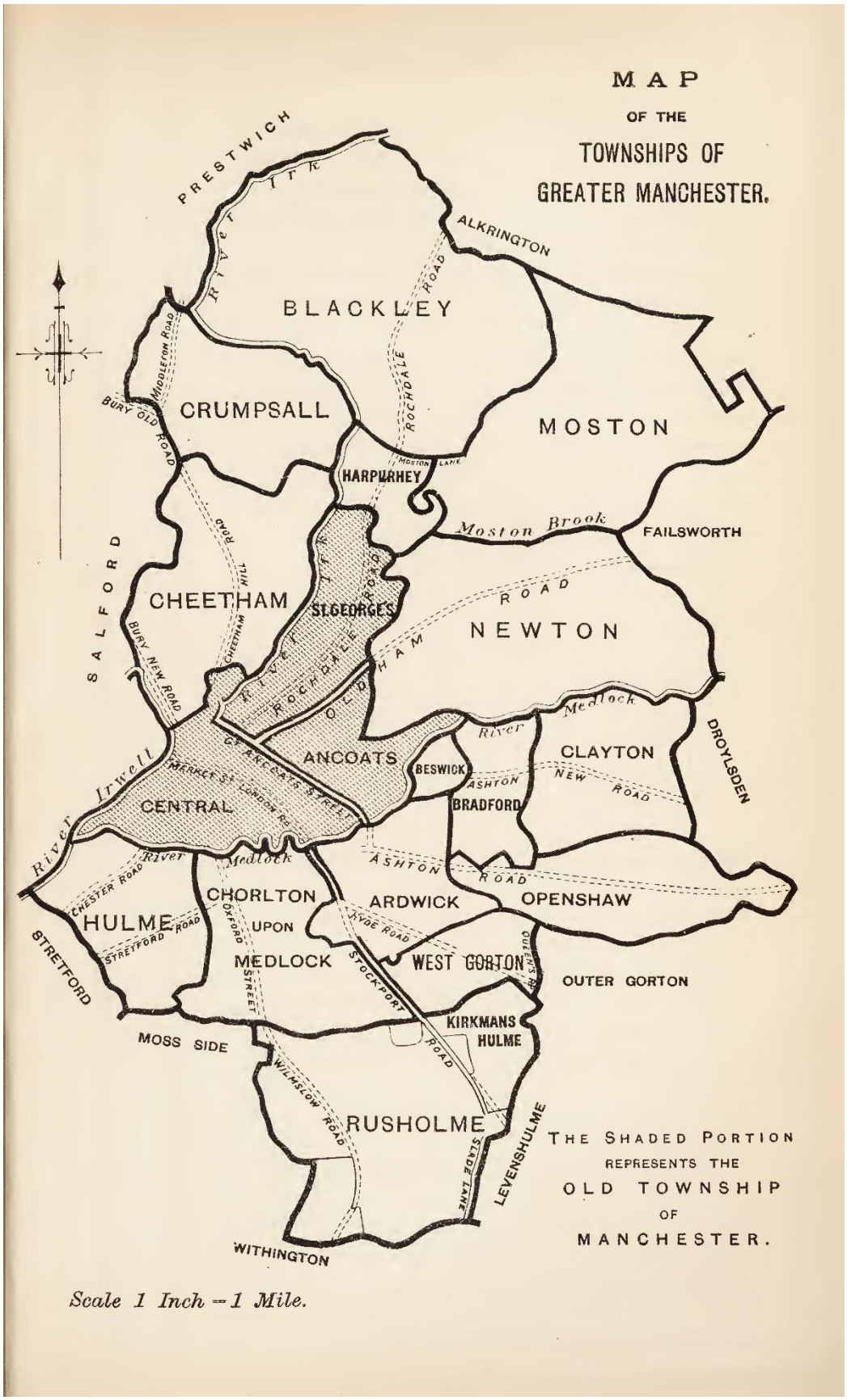


Figure 2-5. Map of Manchester in 1891, showing the 18 statistical divisions
The shaded area on the map is the old inner district of the city (Tatham, 1894).

The rate of growth of Manchester was not as rapid as that seen in Glasgow, and nor was average population density for the city as a whole so high, reaching a peak of 43 per acre in 1904 (Glasgow peaked at 93). Within the city there was again a marked variation in population density; in 1891 Hulme had 152 persons per acre whereas Blackley had only 4 (Tatham, 1894). Even in 1924, Hulme still had a population density of 136 per acre, while the least densely populated district was now Crumpsall with 6 (Veitch-Clark, 1924). Between 1837 and 1970, for the years where data are available, the highest crude death rate in Manchester was 44.5 per thousand population in 1847. This was the result of an outbreak of typhus which, according to the Registrar of Deansgate was 'essentially a famine fever' occurring particularly among immigrants fleeing the famine in Ireland (Registrar-General, 1852, page xx). Records for individual areas of the city were only produced regularly in the Medical Officer of Health reports from 1891 onwards, and at this time the worst performing statistical division was Ancoats with a death rate of 34. For comparison, the worst performing ward in Glasgow in 1891 was Blackfriars, with a very similar death rate of 33. The poor air quality in Manchester was frequently commented upon, being claimed by some to be worse than the famous London smogs (Wohl, 1983). Despite some attempts to reduce industrial pollution via various local Police Acts, which were often laxly enforced (Wohl, 1983), the issue of pollution from the domestic use of coal was not dealt with until the Clean Air Act (1956).

2.4 Data

2.4.1 Glasgow data

2.4.1.1 Data sources

As part of my work for this thesis, I have created a novel dataset of vital statistics, causes of death and other variables for Glasgow 1850-1950 and its constituent administrative areas from 1878-1937. The principal sources of data are the annual reports of the Glasgow Medical Officer of Health and other associated reports such as the Vital Statistics of Glasgow reports and reports of the Sanitary Department. In addition, reports from the Registrar General for Scotland have been consulted, as have the decennial censuses. Copies of the reports that were not available on-line were viewed in the Glasgow City Archives

or Glasgow University Library, and others were accessed via the Wellcome Collection on-line library (Wellcome, 2024) and Online Historical Population Reports (University of Essex, 2024).

Early Medical Officer of Health reports are less complete than those for later years in terms of quantitative data provided. Medical Officer of Health reports for Glasgow were first produced in a relatively short form, mostly consisting of discussion, in 1863 and 1864 (Gairdner, 1863, Gairdner, 1864). The 1871 report provides limited data in a tabulated form for sanitary districts (Gairdner, 1872), as does the 1881 report 'Decennial Census as a Basis for Statistics in Intervening Periods' (Russell, 1881). The 'Report on Uncertified Deaths in Glasgow' (Russell et al., 1876) also provides limited data at the sanitary district level. Detailed data for multiple variables at the sanitary district level 1880-85 are included in the 'Vital Statistics of Glasgow Parts I, II and III' report produced by J. B. Russell, the then Medical Officer of Health, in 1886 (Russell, 1886). There are then no published Medical Officer of Health reports[1] until 1898, but it was possible to transcribe a limited number of variables from the Sanitary Department reports 1887-97, which are held in the Glasgow City Archives (Sanitary Department, 1897).

The Public Health (Scotland) Act 1897 (1897) imposed a legal requirement on Medical Officers of Health in Scotland to provide annual reports, following the Public Health Act 1875 (1875) which introduced this requirement for Medical Officers of Health in England. Reports were to be produced annually and to contain certain specified information. Nevertheless, the length and content of reports varied between areas and appears to have depended to a large extent upon the level of detail preferred by the incumbent Medical Officer of Health. From my readings of reports produced for various cities, it appears that Glasgow's Medical Officer of Health tended to include more quantitative data than comparative reports from, for example, Edinburgh, Dundee, Manchester or Liverpool. The Glasgow reports provide more detail (e.g. covering more individual diseases), cover more individual areas (e.g. wards) and include more variables relating to socioeconomic conditions (e.g. persons per room). These

[1] Reports are mentioned in the Minutes of the Health Committee but no copies of them are held in Glasgow City Archives or The National Records of Scotland.

reports were produced annually in Glasgow until the post of Medical Officer of Health was abolished in 1972 (Wilson, 1972)[2].

The Medical Officer of Health reports, and the dataset created from them, do not provide data at the level of the individual. Work is on-going by the Scottish Historic Population Platform[3], under the auspices of the Scottish Centre for Administrative Data Research, to digitise and link individual records of Scottish births, deaths and marriages from 1855 to 1973. This will provide an enormous and very valuable data resource for future researchers but will nevertheless not include all the variables contained in the Glasgow Medical Officer of Health reports dataset.

2.4.1.2 Data variables

For some years from 1878, and annually from 1891-1937, vital statistics were provided by administrative area (sanitary district or ward). These included population, births, illegitimate births (from 1898), deaths and deaths under one year. The main variable used in the analysis presented here is the crude death rate, defined as the number of deaths per thousand population. This is the headline measure of mortality and is used by many researchers when studying historical mortality (e.g. Omran 1971, Mackenbach 2006, Murtin 2013, Davenport 2020). These data are provided in the Medical Officer of Health reports and are available at both the city and, crucially, small area levels for long periods of time. An additional variable that might have provided further insights is the age-standardised mortality rate, which is useful when the underlying mortality rate may be influenced by the age structure of the population[4]. Age standardised mortality data are not provided in the Medical Officer of Health reports, but it has been possible to calculate them at the small area level for the two years, 1901 and 1911. Using data for these years, the crude death rate and the age-standardised mortality rate have been compared using scatterplots, and there do

[2] The reports for 1899 and 1900 were published jointly, as were the reports for the World War One years 1914-19. Reports during World War two were published in a shortened form.
[3] SHiPP, https://www.scadr.ac.uk/our-research/shipp
[4] For example, if one ward had a larger proportion of children under five in its population, who were known to have had a higher mortality rate in the late nineteenth century, then this would adversely impact on that ward's mortality rate.

not appear to be significant variations, except in Exchange ward (see Appendix 8.1.2, Figure 8-2).

The crude death rate was recorded at the city level for Glasgow annually from 1855 and at the individual sanitary district or ward level from 1878-1885 and then from 1891-1937. Variables required to study the epidemiological transition, such as deaths (and often cases) from the main infectious diseases, were recorded occasionally in the pre-1898 reports, then annually within the Medical Officer of Health reports from 1898-1913 and could be transcribed from handwritten records for 1914-28, but thereafter were unavailable. Cause of death has not been specifically analysed in this thesis, but this information nevertheless provided useful background on the causes of fluctuations in the overall death rate figures.

Variables related to socioeconomic conditions such as persons per room and rooms per dwelling were recorded by administrative area in some but not all years. Persons per room is defined as total population divided by total windowed rooms and rooms per dwelling is defined as total windowed rooms divided by total inhabited houses. Where these data were not available in reports by the Medical Officer of Health or in Sanitary Department reports, information was sought from reports of the Registrar General for Scotland, including the decennial census reports. Although Registrar General reports used registration districts for most of their tables, reports by municipal ward were sometimes included, for example in 1921. Population density, as measured by persons per acre, is available annually in the Medical Officer of Health reports, and the number of illegitimate births is provided annually from 1898. Illegitimate births as a percent of all births is calculated as the number of illegitimate births over the number of total births in that year multiplied by 100.

The number of children vaccinated against smallpox was also recorded by administrative area, and, when conscientious objection to vaccination became legal in Scotland in 1907, data on objection were also recorded. This information is included in the dataset and is used in Chapter 4. A brief discussion of the variables collected, not all of which are used in this thesis, is given in Appendix 8.1.4, Table 8-2.

2.4.1.3 Sanitary districts and municipal wards

In 1871, Glasgow was divided into 24 sanitary districts by Gairdner, the first (part-time) Medical Officer of Health in Glasgow. He decided not to use the existing demarcation of the city into registration districts, used by the Registrar General for Scotland, explaining his reasoning as follows:

> 'the ten Registration Districts formed a subdivision geographically compact enough, but for sanitary inquiries utterly useless, and even misleading, inasmuch as almost every one of these Registration Districts comprises a population not less varied in character than that of the City itself… It thus became apparent that another basis of arrangement must be sought… placing at the disposal of the sanitarian the statistics of such selected districts as appeared to present a certain marked character, as regards the population, from the sanitary point of view' (Gairdner, 1872, p16-17).

His clear motivation for creating these districts was to separate districts with different 'sanitary' characteristics, including what we would now call socioeconomic conditions, to permit a focus on improving the health of the population.

There are two further disadvantages associated with using data at registration district level: firstly, births and deaths were allocated to the district where they occurred, not to the home address of the individual; and, secondly, births and deaths in institutions were allocated to the district where the institution was located (Sinclair, 2000). Both these issues were resolved in the Medical Officer of Health reports, where births and deaths were allocated to the sanitary district/ward of the home address and births and deaths in institutions which could not be allocated back were placed in a (relatively small) separate category of 'Institutions and Harbour' (e.g. Chalmers, 1902b). For the above reasons, registration districts are not used as an area of analysis in this thesis.

By 1902, the number of sanitary districts within Glasgow had grown to 33 and in 1903 these were replaced as the administrative unit used in Medical Officer of Health reports by municipal wards. With movements of the population in the period from 1871, some sanitary districts had grown too large (four had a population above 50,000) and others had become too small to be useful (13 had a population under 10,000) (Chalmers, 1902a). The motivation for replacing the

sanitary districts with municipal wards was to equalise the populations of the units of administration. It was acknowledged that this might create issues of consistency within wards (e.g. parts of the densely populated High Street and Closes East sanitary district were joined to the much less densely populated Dennistoun) but the statistics produced at ward level were considered to be an improvement on sanitary districts as they existed in 1902 (Chalmers, 1902b). The purpose of this change was to allow '[v]ital statistics … [to be] viewed in the light of an intimate knowledge of the local circumstances which influence them' (Chalmers, 1902a).

2.4.1.4 City enlargement and boundary changes

The area covered by the Glasgow Medical Officer of Health reports increased over time as the city expanded and the boundaries of small administrative areas also changed. In 1871 the city comprised of around 6,000 acres, stretching from Dalmarnock and Denniston in the east to Anderston and Park in the west, and from Springburn in the north to Govanhill in the south. In 1891 the size of the city almost doubled to over 12,000 acres with the addition of new areas including Possilpark in the north, Maryhill in the north-west, Kelvinside in the west, and Pollokshields and Langside in the south (see Figure 2-3). In 1912 the city was increased by a further 6,000 acres with the addition of eleven new wards including Partick and Whiteinch in the west, Ibrox and Govan in the south-west, Cathcart in the south and Shettleston in the east, bringing the number of 'old wards' to 37 (Chalmers, 1912b). The ward boundaries were completely redrawn in 1921 creating 'new wards' (Chalmers, 1921). The next enlargement of the city didn't take place until 1927, when an additional 10,000 acres were added, enlarging many of the wards on the outer edges of the city (e.g. Whiteinch, Pollokshields, Springburn) but creating no new wards. This additional area was sparsely populated and only added around 20,000 to a city population which by that point exceeded one million (MacGregor, 1927).

A long time series of consistent geographic areas was needed for analysis, so conversions were made between the various geographies used in the Medical Officer of Health reports. All analysis was conducted using the ward structure that was in place during the period 1903-1920 (the so-called 'old wards'; see

map in Figure 2-4). Data by sanitary districts that existed prior to 1903 were converted to the old ward structure, as were data provided according to the new wards (1921 onwards). There are therefore 25 consistently defined areas for which data is available for the full period 1891-1937, and these are used for most analysis. Ward boundaries were changed again in 1938, but this period is beyond the scope of my analysis, which stops at the Second World War. The data conversion from sanitary districts to the old ward units was carried out by redistributing the values of variables between the different administrative units and is described in Appendix 8.1.5.

2.4.1.5 Glasgow statistics

To set the scene for the analysis that follows, the average crude death rate for the city of Glasgow 1891-1937 is shown in Figure 2-6. The trend of the death rate was generally downward, although there were between-year fluctuations. Despite this downward trend, there were marked inequalities between the death rates of wards throughout the period. Mortality rates for the 25 wards of Glasgow from 1891-1937 are shown in Appendix 8.1.5, Figure 8-3.

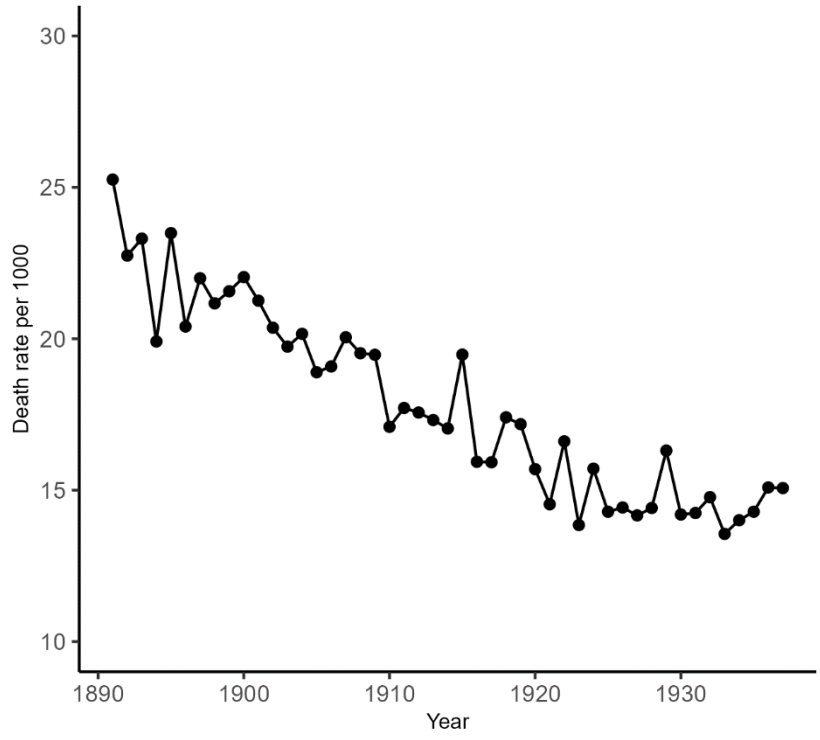


Figure 2-6. Crude death rate for Glasgow 1891-1937

Descriptive statistics for the Glasgow variables are shown in Table 2-1, giving an overview of the data. Crude death rates are given for three key years: 1878, the earliest year in this dataset; 1891, when the city was significantly enlarged; and 1937, the final year of the dataset. It can be seen from these that the mean death rate falls consistently over these years but that the minimum crude death rate first fell and then rose. Possible explanatory variables are given for the first year for which they are available for the full dataset (1891 or 1898). The figures for persons per acre shown the wide disparity in population density in Glasgow in 1891, with some wards having fewer than seven persons per acre whilst others had over 183 persons. These explanatory variables are used in equation [1], except rooms per dwelling 1891 which is too closely correlated with persons per room to be included.

Table 2-1. Descriptive statistics of variables across wards in Glasgow.

Variable	Minimum	Maximum	Mean	Standard deviation
Death rate 1878 (per 1000 population)	17.7	32.9	24.7	3.84
Death rate 1891 (per 1000 population)	9.77	33.0	21.8	5.61
Death rate 1937 (per 1000 population)	12.0	20.9	15.8	2.58
Persons per acre 1891	6.82	183.20	81.85	51.38
Persons per room 1891	0.70	2.57	1.87	0.51
Rooms per dwelling 1891	1.74	7.60	2.96	1.44
Illegitimate births 1898 (as percent of all births)	2.35	13.5	6.67	3.21

Notes: There were 21 wards in 1878 and 25 wards from 1891-1937. Units are provided in brackets where appropriate.

2.4.2 Manchester data

2.4.2.1 Data sources and variables

Sources of data for my research on Manchester 1850-1950 are the annual reports of the Manchester Medical Officer for Health plus reports from the Registrar General for England and Wales and the decennial censuses. All data accessed have been via the Wellcome On-line Library (Wellcome, 2024) or the Online Historical Population Reports (University of Essex, 2024). The Public Health Act 1875 (1875) imposed a legal requirement on Medical Officers of Health in England to provide reports annually[5]. For the analysis of small areas, I used the

[5] The reason why a similar law was not passed in Scotland until 1897 appears to be because the laws dealing with disease and welfare differed significantly from those of England, meaning the English Act could not easily be replicated for Scotland (Hamlin and Sidley, 1998).

Manchester Medical Officer of Health reports from 1891 to 1924, which was a period during which data were recorded for consistent geographical areas called statistical divisions. In 1891 there were 18 statistical divisions (Figure 2-5), with two joining in 1905 (Moss Side and Withington) and a further two in 1910 (Gorton and Levenshulme). In 1891 the average population of these divisions was 28,000, very similar to the average population of Glasgow wards at 26,000.

As with Glasgow, the main measurement used in my analyses of mortality in Manchester is the crude death rate, which is available annually from 1891 to 1924 for 18 statistical divisions. Variables available in the Manchester reports were more restricted than those for Glasgow, comprising principally population figures and vital statistics for births, deaths, persons per acre, illegitimate births and deaths under one year. This provided me with two variables that I could use to estimate socioeconomic conditions: persons per acre (population density) and illegitimate births as a percent of all births. Data were not provided at the statistical division level for three years during the First World War (1915-17). Where it is helpful to have a complete data series, averages of the 1914 and 1918 values have been used for these years. Age structure data are not available for Manchester statistical divisions.

2.4.2.2 Manchester statistics

The pattern of the fall in the death rate in Manchester over the period examined in this chapter is shown in Figure 2-7. As with Glasgow, the death rate generally fell over the period, although there were between-year fluctuations. The change in the death rate over the period for the 18 statistical divisions which existed for all years is shown in Appendix 8.1.7, Figure 8-4. Descriptive statistics for the Manchester variables are shown in

Table 2-2, giving an overview of the data. Crude death rates are given for the entire period. As the four additional divisions (added in 1905 and 1910) only provide a short time series of the relevant data, most of my subsequent analysis is conducted using the 18-division dataset. The two explanatory variables are provided for 1891, the first year of the dataset, and are used in equation [1].

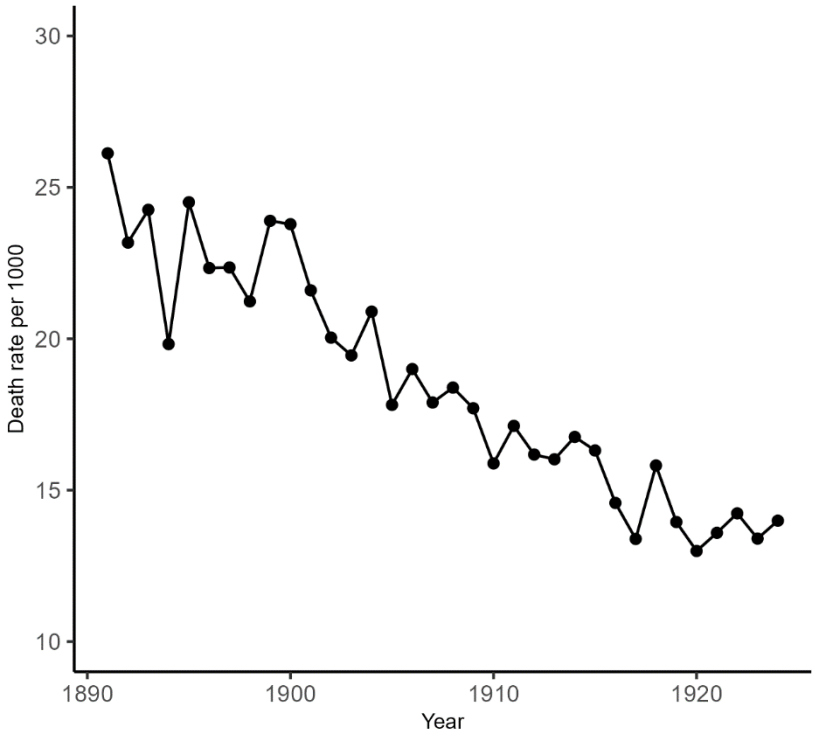


Figure 2-7. Crude death rate for Manchester 1891-1924

Table 2-2. Descriptive statistics of variables for Manchester

Variable	Minimum	Maximum	Mean	Standard deviation
Death rate 1891 (per 1000 population)	17.03	34.17	23.8	5.0
Death rate 1924 (per 1000 population)	9.8	22.85	14.02	3.38
Persons per acre 1891	3.92	152.33	57.66	45.93
Illegitimate births 1891 (as percent of all births)	1.37	8.9	3.57	2.02

Notes: Data are for 18 divisions, 1891-1924. Units are provided in brackets where appropriate.

2.4.3 Using historical records

Civil registration of a death, including the cause of death and the age and sex of the deceased, was introduced into England and Wales in 1837 (Registration Act 1836 (1836)) and Scotland in 1855 (Registration (Scotland) Act 1854 (1854)). Much of the data used in this chapter was produced as a result of these acts, which resulted in consistent annual records which were, generally, more reliable than those that preceded them. A particular advantage of using administrative data for analysis is that the population covered should not be subject to any significant bias: individuals could not opt out of registering births or deaths, once this became legally required (Kashyap, 2021). Many of the quantitative data within the Medical Officer of Health reports are sourced from these registration records, augmented by information collected by the department's

own sanitary officers and medical staff. Data are grouped by geographical area or by disease, or both, providing a record of what was considered at the time to be important, assembled according to current understanding of the sanitary situation of the city (e.g. Chalmers, 1902b, Gairdner, 1872). A number of known issues with using historical data of this sort are summarised in Appendix 8.1.3.

When dealing with data taken from historical records it is important to be aware that they may be inaccurate for reasons such as being incorrectly collected, recorded (at source) or transcribed (into reports). The variables they contain also suffer from selection bias in that only those variables considered of interest by administration officials of the time were recorded. We should therefore bear in mind that many data were not collected and are consequently not available to us. This is particularly the case with measures of socioeconomic conditions, which we now consider of great significance, but which were only recorded patchily if at all in, for example, the Medical Officer of Health reports.

The Medical Officer of Health reports are documents of their time, reflecting the knowledge, terminology and accepted opinions of the era in which they were written. Compared with official reports produced in the twenty-first century, they can appear subjective, moralising and judgemental. For example, Gairdner refers to ‘the debased and degenerate population of the High Street’ (Gairdner, 1872, p16). He seems to assume that this is an acceptable way to talk about poor people, commenting both on their character (‘debased’) and their physical or intellectual abilities (‘degenerate’). Neither the terminology nor the attitude which it indicates would be considered acceptable today. When reading and interpreting these reports, I have tried both to understand the meaning that was intended at the time of writing, and to reflect on whether data or circumstances might be re-interpreted with our current level of understanding.

2.4.4 Data transcription and accuracy checks

To create my Glasgow and Manchester datasets, data from the Medical Officer of Health and other reports, whether printed or handwritten, were manually transcribed into Excel spreadsheets. I undertook trials using optical character recognition software packages (e.g. Adobe and ScanTailor), but I decided not to

proceed with this approach due to the high level of errors encountered. Most errors were the result of the print typeface being faint or blurred, or the spacing between characters being uneven. These errors were particularly frequent when dealing with numerical digits, which were the key components of interest. In addition, some Glasgow data were handwritten in faded pen or pencil which could not be interpreted by any of the software used. Examples of documentation for Glasgow are given in Figure 2-8 and Figure 2-9. Optical character recognition software is improving, but I judged, as have others, that for my data sources, the work of checking for errors after processing was less efficient than manual transcription (see e.g. Katsnelson, 2024).

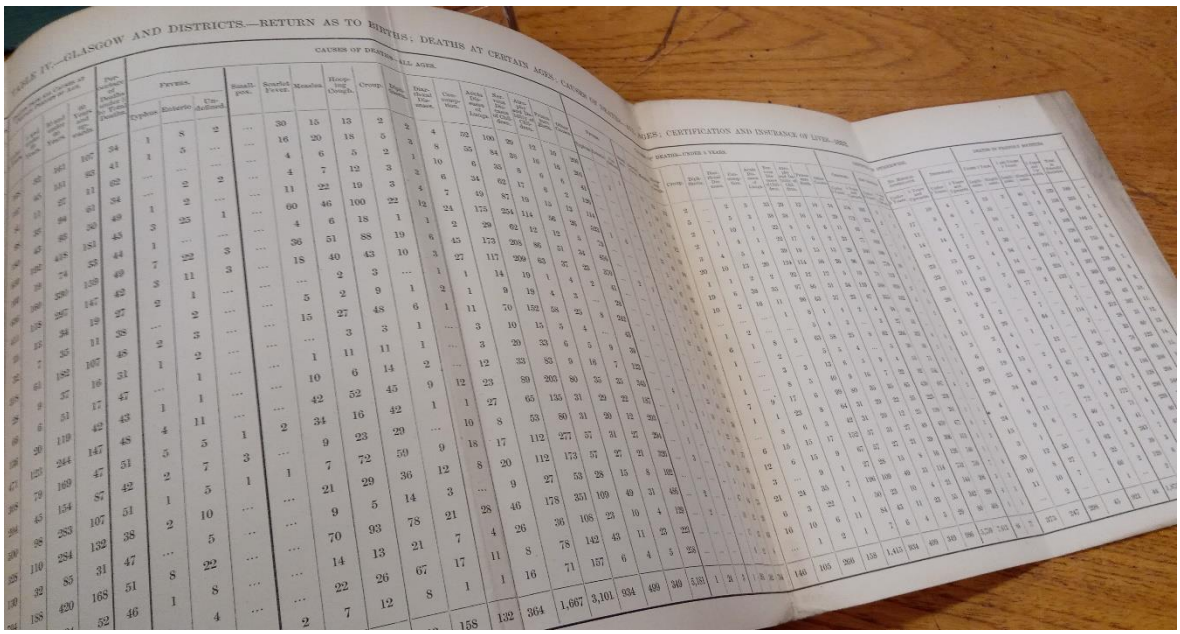


Figure 2-8. A page from 'Vital Statistics of the City of Glasgow'.
(Russell 1886), courtesy of the Glasgow City Archives.

Although manual transcription of data is open to human error, the vast majority of tables in the Glasgow and Manchester Medical Officer of Health reports include column totals, which could be checked against the data entered for accuracy. In addition, some tables included row totals which allowed an even greater level of cross-checking. Where it was possible to cross-check totals, this was done, leading to a high level of confidence to the transcription process. Unfortunately, tables in the reports by Registrar General (either the annual reports or the decennial censuses) rarely include column or row totals, so the

risk of transcription errors is higher with these data. Nonetheless, in terms of the datasets, relatively few variables are sourced from the Registrar General reports.

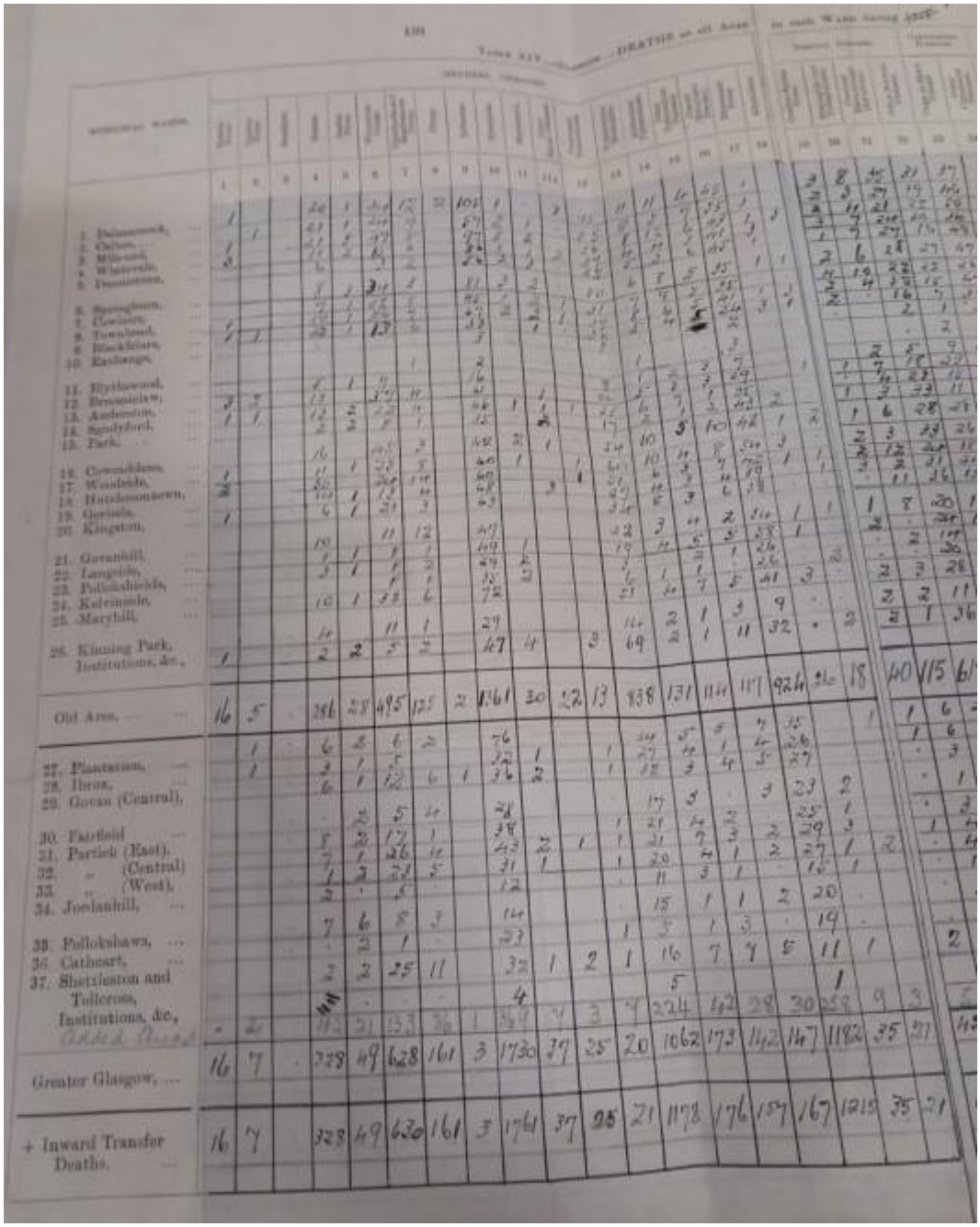


Figure 2-9. An example of handwritten records for Glasgow, 1919
Courtesy of the Glasgow City Archives.

2.4.5 Unique datasets

To my knowledge, no researchers have previously systematically transcribed these data into a digitised format as I have done. The variables recorded include population, births, deaths, cause of death, illegitimate births and a variety of indicators of socioeconomic conditions, creating shareable datasets for Glasgow and Manchester. A full list of over 80 variables collected for Glasgow is given in Appendix 8.1.4. These datasets contain information on the two cities for over 100 years, and on the geographical areas within them for up to 47 years. The creation of these datasets has permitted the construction of additional variables which allow statistical analysis using R or other software. The datasets used in this thesis and the code for the analysis are lodged at 10.5281/zenodo.10817542.

2.5 Results: mortality inequalities and socioeconomic conditions

2.5.1 The mortality penalty

To examine the mortality burden of a specific area relative to the city over the whole period, I construct a variable that I call the mortality penalty. The mortality penalty allows me to examine the mortality burden over the period for which I have annual small area data, from 1891 to 1937 in Glasgow and 1891 to 1924 in Manchester. I first calculate the surplus or deficit of the observed crude death rate for each year for the small area as compared with the observed city death rate for the same year. A surplus indicates a death rate above the city average and a deficit below.

The annual mortality surplus or deficit for Glasgow wards is shown in Figure 2-10, with a number above zero indicating the ward mortality is in excess of the city mortality. This figure suggests that wards with lower socioeconomic conditions, such as Blackfriars and Calton, have a high, although varying, mortality surplus throughout the period. Similarly, wards with higher socioeconomic conditions, such as Langside and Pollokshields, have a large mortality deficit, although this benefit reduces over time. To test this relationship, the total mortality penalty and a number of socioeconomic variables are examined in the statistical analysis presented in Section 2.5.4. An

important result from Figure 2-10 is the persistence of mortality surplus or deficit position, seen in the way the wards are generally either above or below or hover around the zero line, but rarely completely reverse their position. Those wards which do reverse their position, such as Blythswood, are those that saw a significant change in the pattern of land use, as discussed in Section 2.3.1.

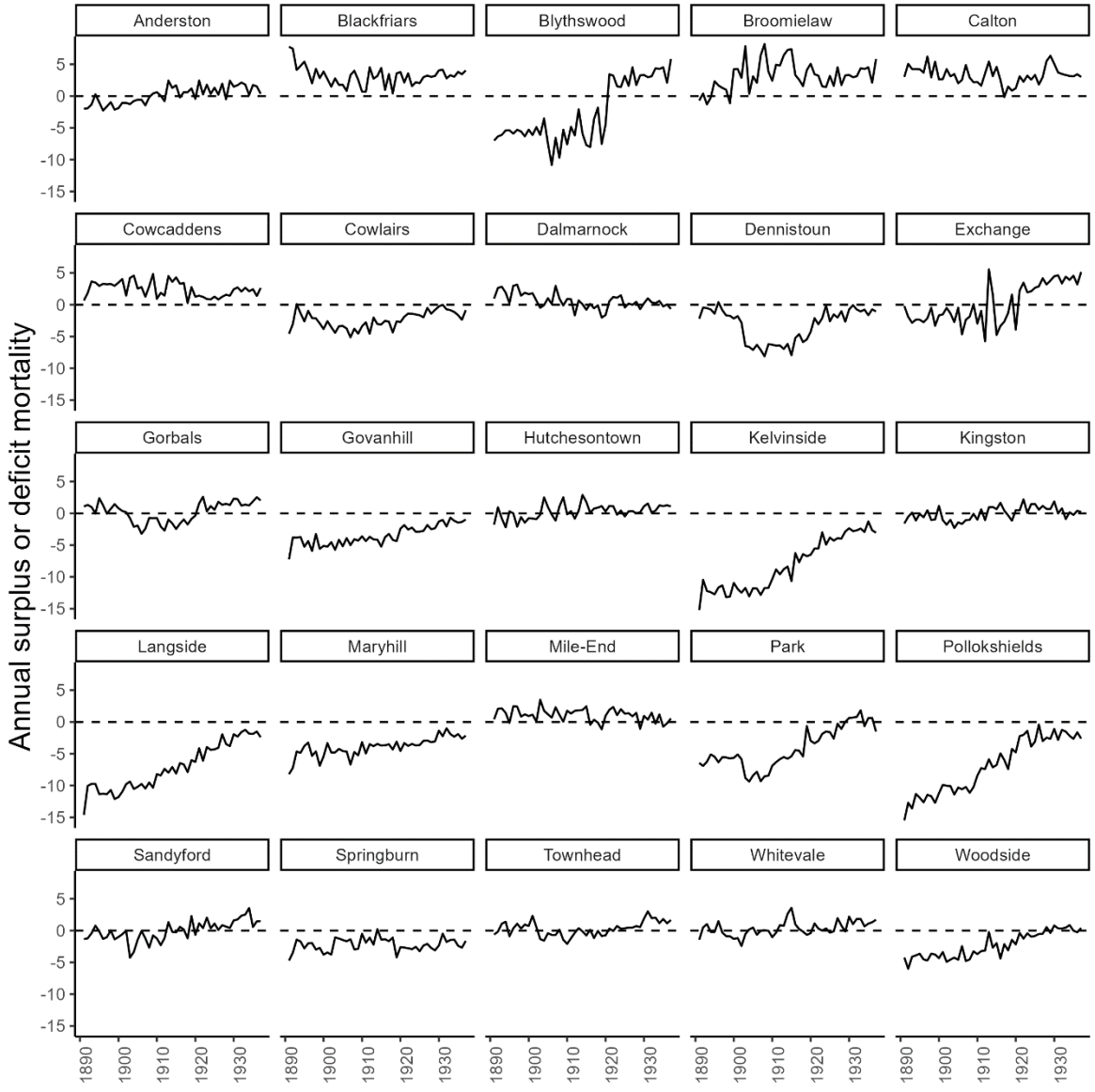


Figure 2-10. The annual mortality surplus or deficit for 25 Glasgow wards 1891-1937
Zero is marked by a dashed line. A positive figure indicates a mortality surplus as compared with the overall city, and a figure below zero indicates a mortality deficit.

The annual surpluses and deficits over the time period are then summed to give the 'mortality penalty', where the higher the number, the worse the area performed over the period, compared with the city average. It is thus a measure of excess mortality – which partials out aggregate effects – over the whole period. The total mortality penalty for each ward is shown in Figure 2-11, where

it can be seen that the better-off wards such as Kelvinside and Langside had a significant mortality deficit over the period, i.e. experienced far lower mortality than the city average.

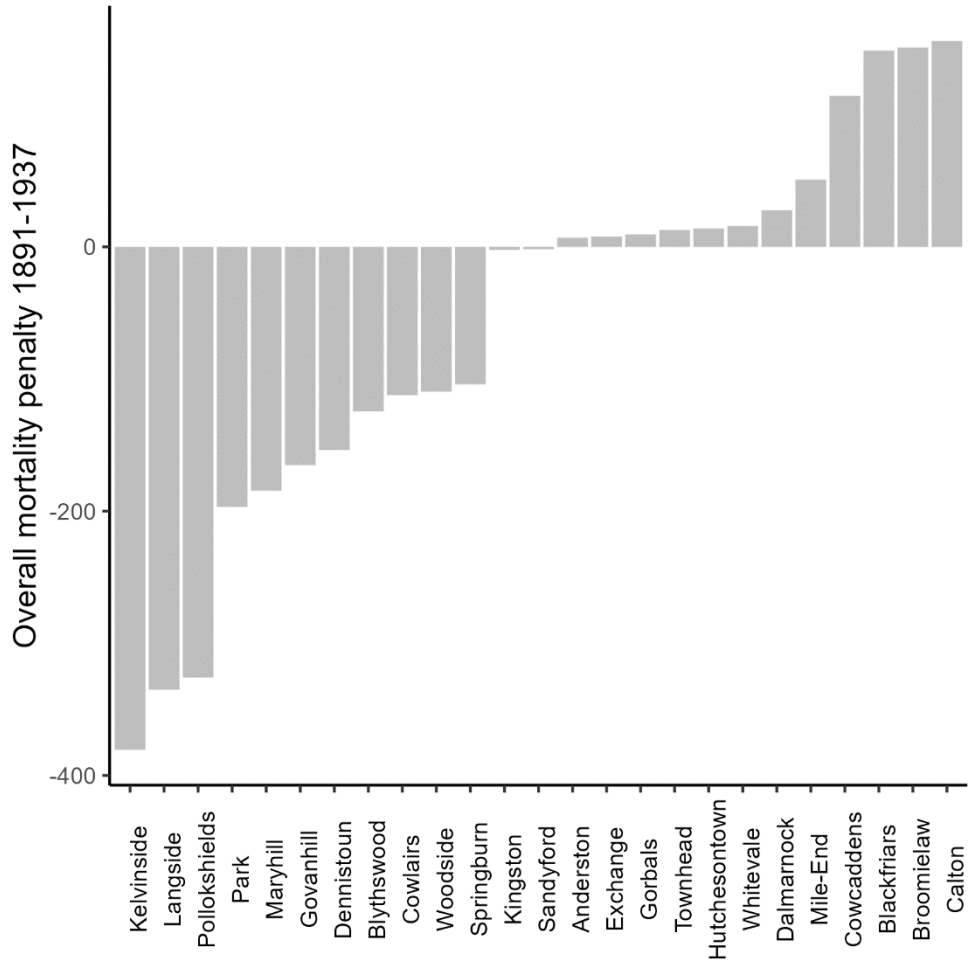


Figure 2-11. The mortality penalty for Glasgow wards from 1891-1937
The mortality penalty is calculated by subtracting the city average death rate from the ward death rate for each year 1891-1937, and totalling the results.

The annual mortality surplus or deficit has also been plotted for the 18 Manchester statistical districts for which I have data 1891-1924 in Figure 2-12. Some wards always have a far higher mortality rate than the city average, such as Ancoats, Central and St George's; these are all wards which have lower socioeconomic conditions, for example, Ancoats and St George's have population densities of over 100 persons per acre until the First World War (the city average is around 35). Areas with a consistent mortality deficit, such as Cheetham, Moston and Rusholme and Kirk, all had lower population density indicative of higher socioeconomic conditions. Once again, areas generally remain either

above or below the zero line, showing the persistent influence of socioeconomic conditions on mortality. The only area whose pattern clearly crosses the zero line was Chorlton-upon-Medlock, which had seen a change in its land use towards the end of the nineteenth century, as mentioned in Section 2.3.2.

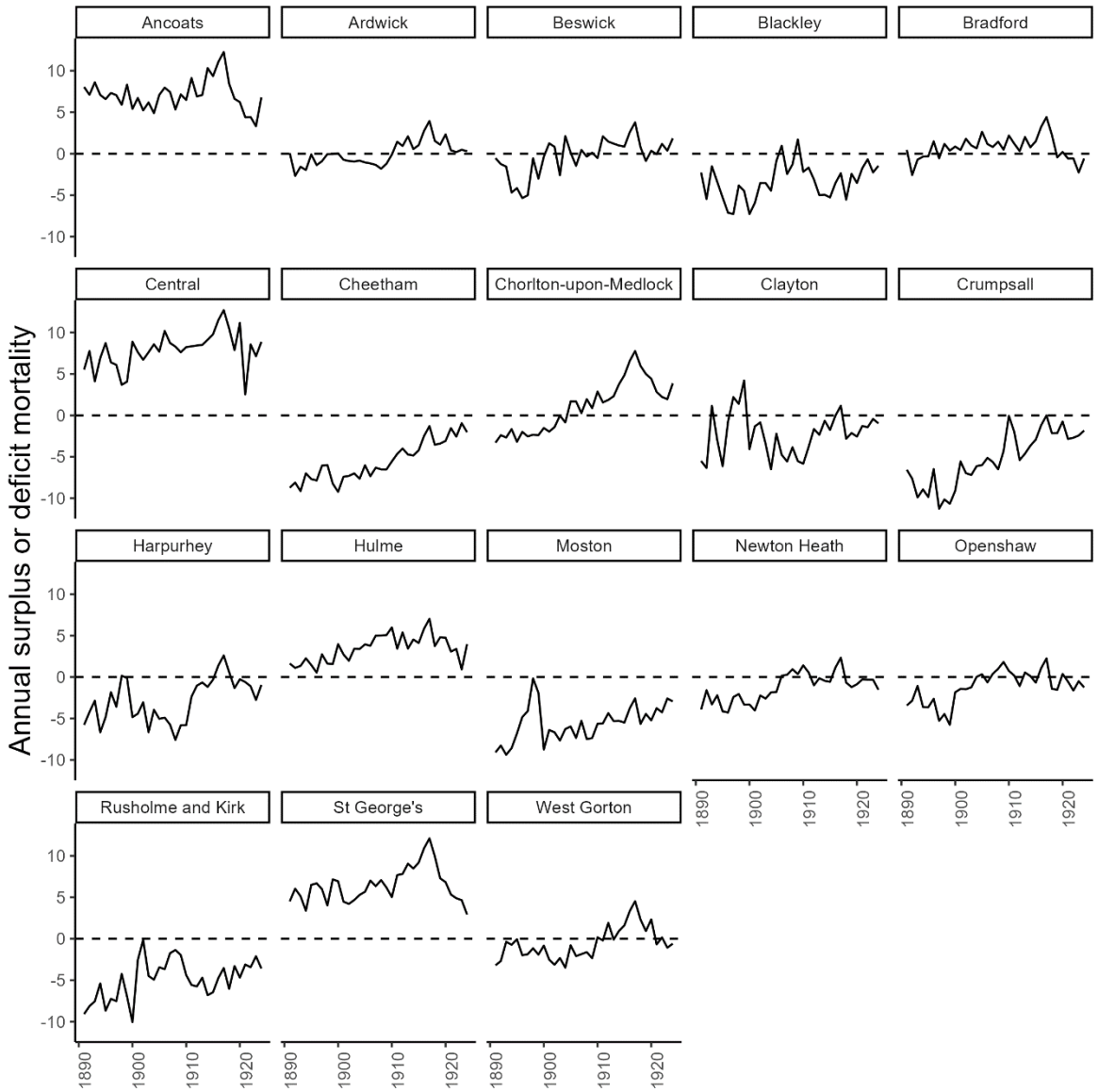


Figure 2-12. The annual mortality surplus or deficit, Manchester
For 18 statistical divisions 1891-1924. A zero is marked by a dashed line. A positive figure indicates a mortality surplus as compared with the overall city, and a figure below zero indicates a mortality deficit.

In both Glasgow and Manchester, we see large variations among the small geographic areas in whether they experience a mortality surplus or deficit as compared with the city average mortality. Figure 2-10 and Figure 2-12 not only show the extent of this variation, but how persistent it was over time, with areas rarely reversing their position from one of consistent surplus mortality to

one of consistent deficit mortality, or vice versa. This way in which areas retain their position over the period is suggestive of the long-lasting effect of socioeconomic conditions on mortality.

2.5.2 End-of-period mortality

To examine mortality at the end of the period for which I have small area data, I compute the average death rate for the last five years in each of the datasets. This end-of-period mortality measure provides an indication of the disparity in mortality rates well after the fall in death rates had begun. The plots of the surplus and deficit mortality in Figure 2-10 and Figure 2-12 showed that at the end of the period in both cities there were marked inequalities between how areas compared to the city average mortality. The average death rates 1933-37 for Glasgow wards are plotted in Figure 2-13 and confirm these clear differences.

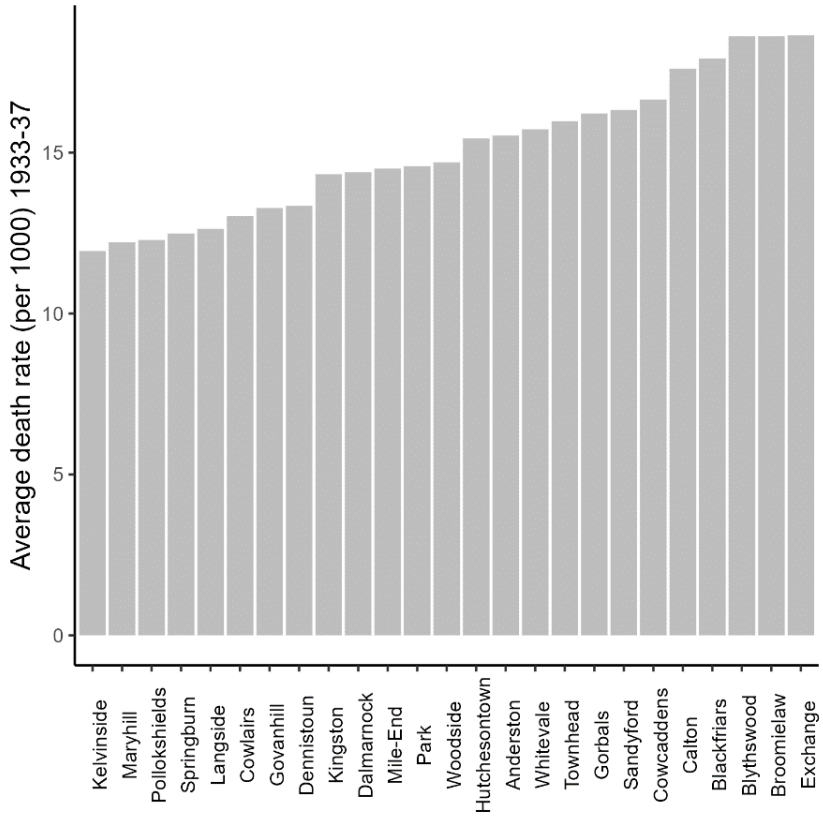


Figure 2-13. Average crude death rate per 1,000 population for 25 wards in Glasgow, 1933-37

There was a gap of 6.7 deaths per 1,000 population between the highest mortality areas (Exchange, Blythswood and Broomielaw) and lowest mortality area (Kelvinside). In the 1930s the joint population of these high mortality wards was around 10,000, meaning they suffered an additional 67 deaths per year

compared to the number of deaths if their mortality rate had equalled that of Kelvinside

The average end-of-period (1920-24) death rates for Manchester divisions are plotted in Figure 2-14 and show a gap of 10.4 deaths per 1,000 population between the highest (Central) and lowest (Moston) mortality areas. The end-of-period death rate in Moston was less than half that in Central, emphasising just how significant the disparity was. Manchester exhibits a greater disparity between the mortality of small areas than seen in Glasgow at the end-of-period, although we should note that the Glasgow time series ends later. If we compare both cities in 1920-24, Manchester still had the largest gap between the highest and lowest small areas, at 10.4 per thousand compared to 8 for Glasgow.

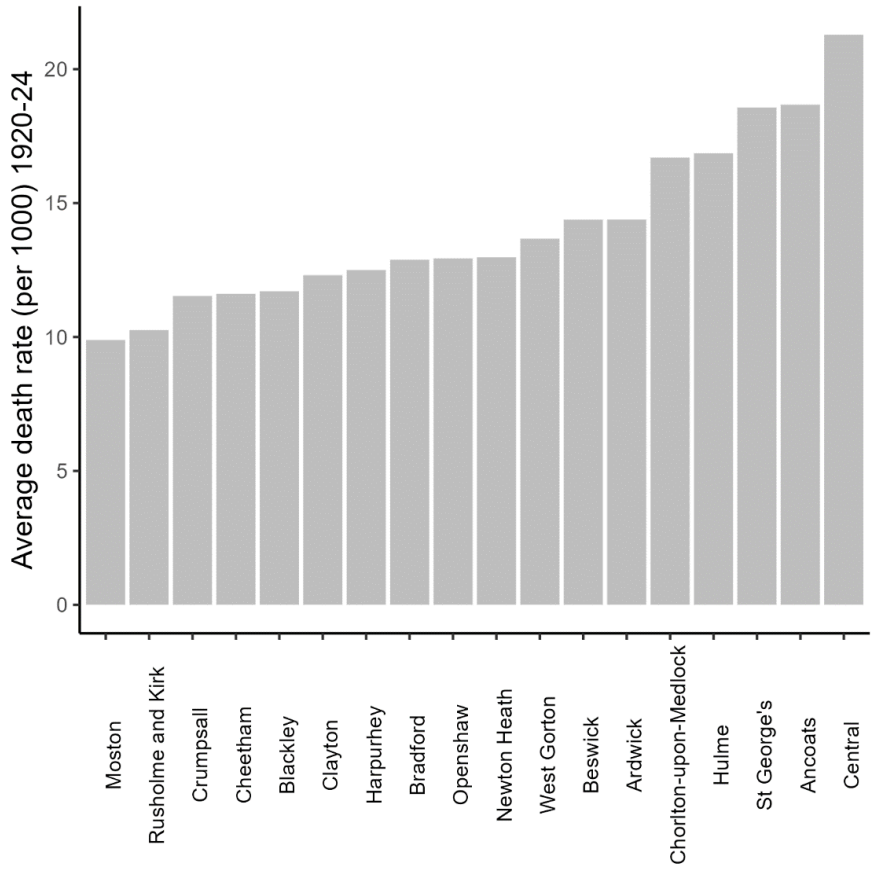


Figure 2-14. Average crude death rate per 1000 population for 18 statistical divisions in Manchester, 1920-24

2.5.3 Statistical model

To analyse the relationship between socioeconomic conditions and mortality, I now use a statistical model to assess the association for the periods where data are available for small areas of the cities. I focus on the association between socioeconomic variables at the beginning of the period and the two dependent variables which measure mortality: the mortality penalty and the average end-of-period observed death rate (both discussed above). The model was specified as

$$y_i = \beta_1 + \beta_2 h_{1i} + \beta_3 h_{2i} + \beta_4 h_{3i} + u_i \qquad [1]$$

for administrative units $i = 1,\ldots,N$. In this specification, y_i is a measure of the dependent variable in administrative unit i (i.e. the mortality penalty or the average end-of-period death rate); h_{1i} is the measure of persons per room (not available for Manchester), h_{2i} is persons per acres and h_{3i} is illegitimate births as a percent of all births; and , u_i is an error term. Similar models have been used by other researchers to examine mortality inequalities (e.g. Cage and Foster, 2002, Jaadla and Reid, 2017, Kesztenbaum and Rosenthal, 2016). The model is estimated using Ordinary Least Squares, but I also undertake a robustness check by repeating the analysis with Bell-McCaffrey heteroskedasticity robust standard errors, which perform well with small samples (Imbens and Kolesar, 2016, McCaffrey and Bell, 2006).

I include different measures of socioeconomic conditions to allow me to examine different aspects of the variation between areas. Persons per room indicates the average number of persons living in a room in each ward. It is both a measure of overcrowding, which increases risks from infectious diseases, and also a marker of income in that poorer families could afford less space per person. This measure is included in the model as it would be expected to be associated with higher mortality levels on both these counts. Persons per acre is a broader indication of population density, considering the wider region rather than the individual house. Higher numbers of persons per room and higher population densities may both have facilitated the spread of disease, making illness and therefore death more likely, although persons per room has been more closely

associated with health outcomes (e.g. Cage, 1994). High rates of illegitimate births are correlated with poverty (Koops et al., 2021) and so are a useful proxy for socioeconomic conditions, especially where other variables are not available. The proportion of illegitimate births is not likely of itself to contribute to higher levels of mortality (except in as much as illegitimate infants did suffer higher mortality (e.g. Chalmers, 1902b)) but may represent other factors that are not measured in the datasets. All the socioeconomic variables are taken from 1891, the first year in which they appear in the data sources, except for percent of illegitimate births in Glasgow which is first available in 1898. These indicators of initial socioeconomic conditions are selected from this early period to avoid any possible influence from subsequent mortality conditions, as reverse causality is known to be an issue when studying socioeconomic conditions and mortality contemporaneously (e.g. Backlund et al., 1996).

A correlation matrix was created for the three Glasgow variables discussed above; see Table 2-3. Although both persons per room and population density might be seen as measures of crowding, they are not strongly correlated with each other. This suggests that they reflect different aspects of the overall availability of space within an area; for example, persons per acre may reflect the presence or absence of parks or other open areas. The percent of illegitimate births is not closely correlated with any of the other variables in [1] so it is likely this represents aspects of socioeconomic circumstances not captured elsewhere. This could, for example, be indicative of attitudes to risk, concern with social norms, or merely a lack of resources to cover up the illegitimacy (Ventura, 1969). Rooms per dwelling was considered as an alternative measure to persons per room, with which it is closely (negatively) correlated, and is also included in Table 2-3. Persons per room was preferred as it was less closely correlated with persons per acre and was indicative of both overcrowding and income. To test for conditional correlations, variance inflation factors were calculated for the variables in [1]: all were under 2, indicating there are no issues with collinearity.

Table 2-3. Correlation matrix for 25 Glasgow wards

	Percent illegitimate births 1898	Persons per acre 1891	Persons per room 1891	Rooms per dwelling 1891
Percent illegitimate births 1898	1			
Persons per acre 1891	0.428	1		
Persons per room 1891	-0.207	0.220	1	
Rooms per dwelling 1891	-0.036	-0.492	-0.730	1

Fewer variables indicative of socioeconomic conditions are available for Manchester so only population density and the percent of illegitimate births, both from 1891, are included in the analyses which follow. These variables are not closely correlated, with a Pearson correlation coefficient of only 0.32.

2.5.4 Statistical analysis: Glasgow

The statistical model suggests that excess mortality in Glasgow over the period 1891-1937 was strongly related to initial socioeconomic conditions. Table 2-4 shows the estimates from the model specification in [1] with the mortality penalty as the dependent variable. Persons per room, population density and the percent of illegitimate births are included separately in Models 1-3, providing estimates of their individual effects. Model 4 includes the three variables together in order to estimate their joint influence. The output is as expected from the literature, with persons per room, population density and percent illegitimate births all individually positively associated with the mortality penalty. Specifically, in Model 1, an increase of one person per room would increase the mortality penalty 1891-1937 by 149, and an increase of one person per acre would increase the mortality penalty by 2.15. The mean mortality penalty over the period was -59.25 (see Figure 2-11 for the mortality penalty by ward). This suggests that overcrowding/lower income, high population density and a high percentage of illegitimate births are individually linked with higher mortality over the period. When the explanatory variables are considered together in Model 4 their strong positive association with the mortality penalty remains. Each variable remains highly statistically significant in the combined model, suggesting that each explains something that is not being captured by the other variables and that all variables contribute to the model. Bell McCaffrey heteroskedasticity robust standard errors are used, which make a correction for small sample sizes (Imbens and Kolesar, 2016, McCaffrey and Bell, 2006).

Table 2-4. Socioeconomic conditions and the mortality penalty, Glasgow

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-348.1*	-256.6***	-211**	-580.6***
	(134.1)	(51)	(61.8)	(78.8)
Persons per room 1891	149*			142.3***
	(62.1)			(35)
Population density 1891		2.15***		1.36***
		(0.44)		(0.288)
Percent illegitimate births 1898			22.74*	18.14*
			(9.76)	(5.71)
R^2	0.279	0.568	0.239	0.815
Number of observations	25	25	25	25

Notes: Estimates shown for the specification in equation [1], for the period 1891-1937. Mean of mortality penalty = -59.25. Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient..

These models show that high initial numbers of persons per room are associated with higher mortality over the period, suggesting that overcrowding and low income may both play a part. High population density is separately associated with a high mortality penalty, suggesting that high levels of building density and a lack of outside open space may also be an issue. We know that a lack of open or green space is associated with poorer health outcomes in more recent times (e.g. Hartig et al., 2014, Mitchell and Popham, 2008, Richardson et al., 2013, Villanueva et al., 2015) and it seems reasonable, knowing how high population density was in late nineteenth and early twentieth century Glasgow, to assume this impact may have been similar or worse at that time. There were open spaces and parks in Glasgow at this time (e.g. Kelvingrove Park in the west Glasgow Green in the east), but these were separate from the dense housing and industrial areas rather than intermingled with them.[6] The percent of illegitimate births acts as a proxy for other aspects of socioeconomic conditions, and these too are associated with a higher mortality penalty. The high R^2 value for Model 4, at 0.82, indicates that a large proportion of the mortality penalty can be explained by these variables. The R^2 value for the joint model is close to the sum of the values for individual influences (Models 1-3), confirming that the variables are capturing different aspects of socioeconomic conditions.

Additional regressions were run to test the robustness of the above results. The models were also run with ordinary standard errors, which as would be expected give higher levels of statistical significance (Table 8-4). Due to the concerns

[6] A more detailed examination of green space in Glasgow in this period might be a fruitful area for future study.

about the differences between the crude death rate and the age standardised mortality rate in one ward (Exchange), discussed in the Section 2.4.1.2, the regressions were also run excluding Exchange. The output was very similar that including Exchange, so any issues about Exchange being a possible outlier do not impact on the analysis; see Appendix 8.1.5, Table 8-3. These checks demonstrate that the results in Table 2-4 are robust.

In order to estimate the relative importance of each of the explanatory variables, the above regressions were repeated using standardised data, which allow comparisons to be made. Data are standardised by subtracting the mean value of each variable from the original values and then dividing by the variable's standard deviation. The mean of each variable is therefore zero and the standard deviation one. These coefficients are displayed in Table 2-5. Standardising variables allows me to compare the strength of the association between each of the explanatory variables and the dependent variable. When the variables are viewed separately (Models 1-3), population density has the strongest association with the mortality penalty. When viewing all the variables together, persons per room has a slightly higher association and percent illegitimate births slightly lower, but all associations are of a similar magnitude, being around 0.4-0.5 of a standard deviation relative to the mean. These results suggest that not only are all variables important to the model, but that their relative influences were also of similar strength.

Table 2-5. Socioeconomic conditions and the mortality penalty, Glasgow (standardised variables)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.000	0.000	0.000	0.000
	(0.184)	(0.141)	(0.188)	(0.098)
Persons per room 1891	0.528*			0.504***
	(0.22)			(0.124)
Population density 1891		0.753***		0.476***
		(0.153)		(0.112)
Percent illegitimate births 1898			0.489*	0.390*
			(0.209)	(0.145)
R^2	0.279	0.568	0.239	0.815
Number of observations	25	25	25	25

Notes: Estimates shown for the specification in equation [1], for the period 1891-1937. Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

In summary, these results imply that there is a strong association between initial socioeconomic conditions and the mortality penalty for small areas of Glasgow during a key period of falling mortality rates. A higher mortality burden is associated with poorer initial socioeconomic circumstances, the most influential of which appears to be persons per room, although population density and percent of illegitimate births also had a negative influence on long-term mortality. If this information had been available to policy makers at the end of the nineteenth century, it would suggest that investments in decreasing the numbers of persons per room and persons per acre in the 1890s could have had a significant positive impact on subsequent mortality levels. In fact, a number of the public health interventions such as the ticketing of houses and the work of the City Improvement Trust (discussed further in Chapter 3), were introduced, but do not appear to have had an appreciable influence on excess mortality, at least when considering the period as a whole. Policy implications of the percent of illegitimate births are more difficult to interpret, as this is likely to be a proxy for other issues which might be addressed, rather than being a matter to be addressed in itself.

I also examined the long-run association of initial socioeconomic conditions with the average end-of-period death rate for Glasgow, 1933-37, to test whether these results varied from those for the mortality penalty. Models 1-4 were run with this alternative dependent variable, and the coefficient estimates are shown in Table 2-6. Persons per room now has no statistical significance at the 10% level or below, but there is a clear positive association between end-of-period mortality and population density and percent of illegitimate births. The models were run using Bell McCaffrey standard errors and the same models with ordinary standard errors are shown in the Appendices, which, as expected, shower higher levels of statistical significance (see 8.1.9 Table 8-5). The table below suggests that an increase of one in population density (i.e. one more person per acre) was associated with an increase in the average end of period mortality rate of 0.03. The mean average end of period death rate was 15.1 (see Figure 2-13 for the end of period death rate by ward). In Section 2.5.2 we saw that there were marked inequalities in mortality rates in Glasgow in the 1930s. The results in Table 2-6 suggest that these inequalities were closely associated

with socioeconomic conditions 40 or more years earlier, specifically with population density and the percent of illegitimate births.

Table 2-6. Socioeconomic conditions and average end-of-period death rate, Glasgow

	Model 1	Model 2	Model 3	Model 4
(Intercept)	15.0***	12.4***	11.6***	10.4***
	(2.66)	(0.483)	(0.414)	(1.64)
Persons per room 1891	0.0615			0.177
	(1.19)			(0.657)
Population density 1891		0.0291***		0.0181**
		(0.0043)		(0.0055)
Percent illegitimate births 1898			52.6***	40.6**
			(6.36)	(10.22)
R2	0.000	0.510	0.624	0.799
Number of observations	25	25	25	25

Notes: Estimates shown for the specification in equation [1], for end of period death rate (1933-37). Mean average end of period death rate = 15.1. Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The relative importance of the explanatory variables is shown when the data are standardised; see Table 2-7. When considered separately, a one standard deviation increase in both population density and proportion of illegitimate births is associated with above a 0.7 standard deviation increase in mortality relative to the mean. When all variables are included in the same model, the influence of the proportion of illegitimate births is now larger than that of population density, with a one standard deviation increase in the percent of illegitimate births being associated with a 0.61 standard deviation increase in the average end-of-period death rate. The influence of initial persons per room is not only no longer statistically significant, but also weak.

Table 2-7. Socioeconomic conditions and average end of period death rate, Glasgow (standardised variables)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.000	0.000	0.000	0.000
	(0.218)	(0.149)	(0.131)	(0.106)
Persons per room 1891	0.015			0.044
	(0.295)			(0.163)
Population density 1891		0.714***		0.444**
		(0.106)		(0.135)
Percent illegitimate births 1898			0.790***	0.610**
			(0.095)	(0.154)
R^2	0.000	0.510	0.624	0.799
Number of observations	25	25	25	25

Notes: Estimates shown for the specification in equation [1], for end of period death rate (1933-37). Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The importance of initial socioeconomic conditions has been confirmed in this analysis of end-of-period mortality in small areas of Glasgow prior to the Second World War. As with the mortality penalty, higher mortality rates are associated with lower initial socioeconomic circumstances, although this time the strongest influences are population density and percent of illegitimate births. To try to conceptualise this, it is helpful to know that a one standard deviation of the average end-of-period death rate was 2.14 per 1000 population (with an average death rate of 15.1). If it had been possible to reduce population density by 0.44 of a standard deviation in 1891 (a reduction of around 23 persons per acre), according to this model, this might be associated with a significant fall in mortality: assuming the average population of Glasgow was around one million at this time, this could equate to around 2,000 fewer deaths per year in the 1930s. We cannot, of course, be sure that the association between these variables is causal, but the strength of the relationship suggests that an improvement in the circumstances of those who lived in lower socioeconomic areas may well have led to an improvement in end-of-period mortality rates. The influence of socioeconomic conditions is likely to have worked through a number of channels that are not identified in this analysis, although one could speculate that, for example, lower population density might lead to less spread of infection and lower levels of air pollution.

There is a key difference between the models shown in Table 2-4 and Table 2-5 as compared with Table 2-6 and Table 2-7; persons per room is significantly associated with a high mortality penalty but it is not significant when examining end-of-period mortality. This suggests that a higher total mortality surplus over the whole period 1891-1937 was associated with higher initial levels of overcrowding and lower initial levels of income, but that the influence of these factors dissipated over time and had far less impact on the end-of period mortality. This may be precisely because of the interventions that were undertaken by the Glasgow city authorities to tackle overcrowding, which took time to have an impact on mortality, but appears to have done so by the 1930s. The socioeconomic measures which are closely associated with end-of-period mortality are population density and the percent of illegitimate births. When the data are standardised it can be seen that the influence of the percent of illegitimate births is the strongest of all the explanatory variables. This suggests

that underlying social factors were more persistent, with their effect possibly propagated and amplified over time, and were not so easily ameliorated by, for example, policy interventions. As discussed previously, this may represent differing attitudes and social norms (as discussed in e.g. Ventura, 1969) or differing underlying factors that are less amenable to policy changes, such as peer influence and social support (Braveman, 2023, Marmot and Wilkinson, 2006). Although we cannot say exactly what this measure is representing, it appears to have had a significant association with both the whole-period mortality penalty and the end-of-period mortality.

The findings of these statistical models confirm what we would expect from the literature, namely that socioeconomic conditions matter for mortality. Specifically, they illustrate that for small areas of Glasgow, the socioeconomic conditions in the late nineteenth century mattered for mortality over the next five decades (the mortality penalty) and for end-of-period mortality, which in this dataset is 47 years later. This long-lasting influence confirms the research of Orford et al in London, that socioeconomic conditions cast a shadow far into the future (Orford et al., 2002). The availability of three separate indicators of socioeconomic conditions allows me to highlight different ways this influence may act, with, for example, overcrowding as indicated by persons per room having less of a long-term association with mortality than population density. This may indicate that some of the policy interventions that are known to have been made by the municipal authorities had an impact on the dangers associated with overcrowding in Glasgow but less on wider population density issues.

2.5.5 Statistical analysis: Manchester

Analysis of the association between socioeconomic conditions and mortality was also undertaken for Manchester. Two versions of the regression model shown in equation [1] were run for Manchester statistical divisions: the first uses the mortality penalty as the dependent variable, the calculation of which is explained in Section 2.5.1, and the second uses the average end-of-period death rate, which here is for 1920-24. Fewer explanatory variables exist in the Manchester dataset, but population density and the percent of illegitimate

births, both from 1891, are available. Bell McCaffrey standard errors are again used.

Coefficient estimates with the mortality penalty as the dependent variable are shown in Table 2-8, with the explanatory variables included separately in Models 1 and 2 to estimate their individual effects, and jointly in Model 3. These estimates show a positive association between the mortality penalty and both population density and the percent of illegitimate births. For example, in Model 1, an increase of one person per acre would increase the mortality penalty 1891-1924 by 2.35. The mean mortality penalty over the period was -11.87. The association between population density and mortality is the strongest statistically, and this suggests that high population density may have been a significant contributory factor in areas where the mortality penalty was high. The statistical significance of the results increases when using ordinary standard errors; see Appendix 8.1.10, Table 8-6. Although only two explanatory variables are available, Model 3 has a relatively high explanatory value with and R^2 value of 0.68 (it is interesting to note that the equivalent R^2 value for Glasgow using only these two explanatory variables is lower at 0.60).

Table 2-8. Socioeconomic conditions and the mortality penalty, Manchester

	Model 1	Model 2	Model 3
(Intercept)	-147.28**	-157.32**	-219.99**
	(36.2)	(51.9)	(60.9)
Population density 1891	2.35**		1.98*
	(0.552)		(0.721)
Percent illegitimate births 1891		40.71*	26.34
		(16.11)	(33.65)
R2	0.557	0.324	0.679
Number of observations	18	18	18

Notes: Estimates shown for the specification in equation [1], for the period 1891-1924. Mean mortality penalty over the period = -11.87. Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The analysis was repeated with data standardised to facilitate comparisons between explanatory variables; see Table 2-9. This shows that, relative to the mean, a one standard deviation increase in population density 1891 is associated with 0.746 standard deviation increase in the mortality penalty (Model 1). In the combined model, the influence of population density reduced slightly to 0.628, but is still almost twice as strongly associated with higher mortality as the

percent of illegitimate births, with a one standard deviation increase in the percent of illegitimate births 1891 only being associated with a 0.368 standard deviation increase in the mortality penalty (but no statistical significance). Initial high levels of population density, representing as they do a lack of outdoor space and likely higher levels of pollution, appear to be the most important factor influencing mortality in Manchester between 1891 and 1924.

Table 2-9. Socioeconomic conditions and the mortality penalty, Manchester (standardised variables)

	Model 1	Model 2	Model 3
(Intercept)	0.000	0.000	0.000
	(0.174)	(0.213)	(0.167)
Population density 1891	0.746**		0.628*
	(0.175)		(0.229)
Percent illegitimate births 1891		0.569*	0.368
		(0.225)	(0.470)
R2	0.557	0.324	0.679
Number of observations	18	18	18

Notes: Estimates shown for the specification in equation [1], for the period 1891-1937. Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. Number of observations: 18 statistical divisions; *** p < 0.001; ** p < 0.01; * p < 0.05; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The association between socioeconomic conditions and the end-of-period death rate in Manchester is examined in Table 2-10. This shows that, individually and jointly, both socioeconomic variables have a statistically significant positive association with the average death rate 1920-24. The mean average death rate for 1920-24 was 14.1. The statistical significance of the results increases when using ordinary standard errors (see Appendix 8.1.10, Table 8-7).

Table 2-10. Socioeconomic conditions and average end of period death rate, Manchester

	Model 1	Model 2	Model 3
(Intercept)	11.23***	10.095***	8.910***
	(0.78)	(1.04)	(1.17)
Population density 1891	0.049***		0.037*
	(0.01)		(0.014)
Percent illegitimate births 1891		1.11**	83.91
		(0.31)	(64.31)
R2	0.516	0.509	0.777
Number of observations	18	18	18

Notes: Estimates shown for the specification in equation [1], for end of period death rate (average death rate for the five years 1921-24). Mean average death rate for 1920-24 = 14.1. Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The coefficient estimates from standardised data (Table 2-11) show that population density 1891 and percent of illegitimate births 1891 both have a similar association with the average end-of-period death rate in Manchester. Here, a one standard deviation increase in either variable separately is associated with around 0.7 standard deviation increase in the average death rate 1920-24. The association of each reduces to around 0.5 standard deviation in the combined model, although the association with illegitimate births loses any statistical significance. The use of standardised coefficients confirms the importance of initial socioeconomic conditions for subsequent mortality in Manchester, and suggests that the socioeconomic conditions as indicated by these two measures have roughly equal influence on long term mortality differentials.

Table 2-11. Socioeconomic conditions and average end of period death rate, Manchester (standardised variables)

	Model 1	Model 2	Model 3
(Intercept)	0.000	0.000	0.000
	(0.18)	(0.18)	(0.14)
Population density 1891	0.718***		0.546*
	(0.15)		(0.204)
Percent illegitimate births 1891		0.714**	0.539
		(0.198)	(0.413)
R2	0.516	0.509	0.777
Number of observations	18	18	18

Notes: Estimates shown for the specification in equation [1], for end of period death rate (average death rate for the five years 1921-24). Least squares estimate, with Bell McCaffrey standard errors shown in parentheses. Number of observations: 18 statistical divisions; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

In Section 2.5.2 we saw that significant mortality inequalities existed in Manchester 1920-24, with the death rate in the lowest mortality area being less than half that of the highest mortality area. Table 2-10 and Table 2-11 suggest that these differences in mortality were associated with initial socioeconomic conditions. As with Glasgow, initial measures of population density and illegitimate births in 1891 appear to have had a long-term impact on mortality, in this case on the death rate over thirty years later. Although the Manchester dataset covers a shorter period than that of Glasgow, it again illustrates that, for small areas of a major British city, the socioeconomic conditions in the late nineteenth century mattered for mortality over the coming decades (the mortality penalty) and for the end-of-period mortality, which in this dataset is

34 years later. As with Glasgow, the influence of percent illegitimate births appears to be larger on end-of-period mortality than it was on the whole-period mortality penalty, suggesting again the long-lasting influence of underlying attitudes and social norms that may be represented by this measure.

2.6 Discussion: Socioeconomic conditions and persistent small area mortality inequalities

Glasgow and Manchester experienced mortality inequalities in the late nineteenth century which continued into the third and fourth decades of the twentieth century. Areas with high initial socioeconomic conditions both started and ended with lower death rates, confirming findings in the literature that higher socioeconomic conditions are related to lower mortality. I am able to separate out the influences of different indicators of socioeconomic conditions, and my findings suggest that the impacts of population density and illegitimate births as a percent of all births were both long-lasting.

In Glasgow, initial socioeconomic conditions are associated with the mortality penalty, which is an indicator of excess mortality over the period 1891-1937. There is a strong positive association between the mortality penalty and initial persons per room, a marker of overcrowding and low income. There is also a positive association between the mortality penalty and two other explanatory variables, population density in 1891 and percent of illegitimate births in 1898, with persons per room having the largest influence when variables are standardised. This suggests that the socioeconomic conditions in an area at the beginning of the mortality transition had long-lasting effects, with influences perceptible for those who lived in these areas over the 40-to–50-year period which followed.

The end-of-period mortality for Glasgow is also associated with certain socioeconomic conditions. There is, however, a key difference between results for the mortality penalty and those for the average end-of-period death rate, in that persons per room has a strong association with the former but appears to have no statistically significant link with the latter. A possible explanation for this is that municipal interventions aimed at reducing overcrowding did not have

an immediate impact, but did have an influence by the end of the period. The association between population density and the percent of illegitimate births and end-of-period mortality is strong and statistically significant. This suggests that the end-of-period mortality in Glasgow was influenced by population density decades earlier, with areas that were densely populated in 1891 continuing to bear a disproportionate burden of higher mortality levels 47 years later. Population density relates to the area outside rather than within the home, and this association may indicate the long-term impacts of such factors as a lack of easily accessible open space or higher levels of air pollution. The lasting influence of percent of illegitimate births, which is a proxy for socioeconomic conditions, may indicate that this variable represents things that are harder to influence than, for example, the size of the home, such as social norms and attitudes.

The three explanatory variables available for Glasgow allow me to identify the way different aspects of socioeconomic conditions have different influences on mortality. The mortality penalty is positively associated with all three variables jointly, suggesting that overcrowding within the home, lack of space/clean air outside the home, and the conditions that percent of illegitimate births is representing all influenced the whole-period mortality position. A high number of persons per room in 1891 does not, however, appear to influence end-of-period mortality, with the main variables associated with this being population density and percent illegitimate births, i.e. the environment outside the home, and social attitudes or other aspects which may be indicated by the percent of illegitimate births.

Fewer markers of socioeconomic status are available for Manchester, but these too show an association between lower socioeconomic conditions at the start of the period and a higher mortality penalty. Of the two explanatory variables (population density and percent of illegitimate births) initial population density shows the strongest association with the mortality penalty, with percent of illegitimate births being less strong and less statistically significant. This suggests that, in Manchester, excess mortality over this period was most strongly associated with how built-up an area was, so that lack of open space and exposure to pollution may both have been a problem.

The end-of-period mortality in Manchester is strongly associated with both the explanatory variables, and the influences of the two appear to be roughly equal. This suggests that that population density in 1891 had an influence on mortality over thirty years later, but that the percent of illegitimate births, a less easily defined effect, was equally important. It is not possible to say exactly what this variable represents but, as with Glasgow, it is likely to be indicative of social attitudes and norms.

Looking at excess mortality over the period studied as a whole, or at the end-of-period average mortality, both Glasgow and Manchester exhibited large differentials between areas of the cities. My research shows that these differentials were associated with socioeconomic conditions in the late nineteenth century, whose influence appeared to last far into the twentieth century. This long term influence of socioeconomic conditions is important for two reasons: firstly, it suggests that if socioeconomic conditions can be improved, the impact on future mortality is likely to be significant; and, secondly, given the benefits which are known to accrue following a fall in mortality rates (e.g. lower fertility, higher education and improved acquisition of human capital (Dyson, 2010, Galor, 2005, Galor, 2011, Kalemli-Ozcan et al., 2000, Murtin, 2013)), these changes are likely to be associated with increased income levels in the future. At the end of the period studied, 1937 in Glasgow or 1924 in Manchester, mortality inequalities persisted, meaning that the other inequalities linked with these are also likely to have remained.

Chapter 3 Heterogeneity in the dynamics of the mortality transition in small areas of Glasgow and Manchester

3.1 Introduction

As discussed in Chapter 2, the mortality transition describes the historically significant fall in death rates, from generally high rates of over 30 per thousand population to sustained low rates of around 10-12 per thousand, seen first in western Europe and North America. Death rates initially began to fall in the second half of the eighteenth century, but with the start of industrialisation, initially in England, they rose again during the early nineteenth century. The higher levels of mortality seen in this period are often attributed to the effects of increased urbanisation, with no effort made initially to deal with the health consequences of the over-crowding that resulted (e.g. Szreter, 1988). Death rates began a sustained fall from around 1870 to around 1950 (Dyson, 2010, Mitchell, 2003), and this is often referred to as the mortality transition (see e.g. Omran, 1971). In Chapter 2 I examined mortality inequalities within the cities of Glasgow and Manchester from 1891 to 1937 and 1924 respectively. I found that these inequalities were associated with differing socioeconomic conditions at the start of the period, with these historical levels of socioeconomic status having a long-term impact on mortality inequalities. The mortality transition is a dynamic process and the influence of socioeconomic conditions on that process is explored in this chapter.

The secular fall in mortality rates has been attributed to a variety of causes. Public health and other interventions in the late nineteenth and early twentieth centuries are likely to have contributed. During the latter half of the nineteenth century, municipal authorities began to involve themselves in health matters, first with the provision of clean water and later the handling of sewage. National governments also made changes which contributed to the falling death rate, such as laws extending compulsory education, and requiring the notification of various infectious diseases which enabled quarantine to be enforced (Dyson, 2010, Szreter, 1988). The reduction in mortality was first seen in young children,

specifically in those aged one to five years, and was due to reduced deaths from the infectious diseases of childhood and water-borne infections linked to diarrhoea (Dyson, 2010, Preston and Nelson, 1974). In the mid-nineteenth century over half of deaths in England and Wales resulted from infectious diseases but by 1930 this had fallen to around a quarter of deaths (Omran, 1971). This dramatic fall in the importance of infectious diseases was termed the 'epidemiological transition' by Omran (Omran, 1971). However, not all countries, or areas within them, experienced these benefits at the same time.

To understand the pattern of the fall in mortality rates, it is necessary to have a sufficiently long time series. When such a series is available, it can be seen that the trend in the fall in mortality rates follows a sigmoid shape (S-shaped curve) well fitted by the logistic function. I have sufficiently long time series for the countries of Scotland and England and Wales and the cities of Glasgow and Manchester. In addition, the unique data series I have created for the small areas of Glasgow from 1878-1937 also allows the fitting of the logistic function for many wards, allowing me to analyse how the mortality gap between high and low mortality areas altered during the mortality transition. In a joint paper (Angelopoulos et al., 2024), we further analyse these data alongside similar data for London. Analysis of trends for small areas shows that the mortality transition happened at different times in different areas of the same city, with key parameters such as the inflection year being earlier for low mortality/high socioeconomic areas. I have also created a shorter time series for Manchester 1891-1924, again drawn from Medical Officer of Health reports.

Although it is clear that the death rate fell for all sections of the population of Europe and north America from around 1870, there is less consensus on whether the gap between high mortality and low mortality areas narrowed or not. Fundamental cause theory, which states that unequal access to resources will inevitably lead to inequalities in health and mortality, suggests that mortality inequalities will only fall if income inequalities fall (Phelan and Link, 2013). As far as can be ascertained from incomplete data, there appears to be little reduction in income inequalities in Britain until at least 1911 (Lindert, 2000). Using data from a range of countries, researchers have found differing results regarding changes in mortality inequalities. Some researchers have found no

convergence in death rates between higher and lower mortality areas, even though mortality outcomes started to improve from around 1870, for example in two US cities (Costa and Kahn, 2015). Others have shown that differentials in infant mortality declined consistently, at least until the 1950s, for UK regions (Congdon et al., 2001), as did inequalities in life expectancy between 1880 and 1980 for French *départements* (Bonnet and d'Albis, 2020).

To analyse the data, I use logistic functions fitted to long time series of mortality rates. I do this at the country and city level, and also for different areas of the cities to understand whether there was no change, divergence or convergence between mortality rates in different small areas of Glasgow and Manchester. I further use plots of the coefficient of variation of the mortality rates for both cities to provide additional insight into this issue.

My analysis shows that, initially, because the wealthier, lower death rate areas improved first, mortality inequalities within the two cities I study were amplified. Subsequently the poorer, high death rate areas also benefitted from falling mortality rates, and the gap between the two narrowed. Measures of the coefficient of variation confirm that there was, initially, divergence in mortality rates among small areas of Glasgow and Manchester after 1891, with convergence only beginning around the time of the First World War.

One way to interpret the gaps between different small areas of the cities during the mortality transition is to compare small area mortalities to the city average and calculate how many years they are ahead of or behind the city. Using this measure, I show that there was a gap of over three generations between areas with a higher and a lower death rate in both Glasgow and Manchester in the 1890s. Although this had reduced by the end of the period studied, the gap remained substantial, at around two generations. Differences in initial socioeconomic conditions at the beginning of the mortality transition are related to these observed patterns.

The remainder of this chapter is set out as follows. Section 3.2 summarises literature on the mortality transition. Section 3.3 provides background on the cities of Glasgow and Manchester and their public health and other

interventions. Section 3.4 discusses the sigmoid pattern of mortality dynamics. Section 3.5 considers the mortality dynamics of the small areas of both Glasgow and Manchester. Section 3.6 presents an interpretive tool for thinking about differences in mortality between small areas of the two cities; and Section 3.7 concludes with a discussion of mortality dynamics.

3.2 Literature review: mortality transition

Over the period 1750-1950, mortality rates in the western world fell drastically, from over 35 per thousand population to around a third of that level (Dyson, 2010). In countries which industrialised early, of which the United Kingdom is a leading example, death rates actually rose again during the second quarter of the nineteenth century, this rise being ascribed to the impact of rapid urbanisation and its epidemiological consequences (Szreter and Mooney, 1998, Woods, 1985). The death rate in the United Kingdom began a secular fall in the third quarter of the nineteenth century and this decline continued until the 1950s (Mitchell, 2003). This significant and sustained reduction, which was eventually seen across the world, is known as the mortality transition (Omran, 1971). The fall in mortality levels was first seen in young children, specifically in those aged one to five years, and was due to reduced deaths from infectious diseases, such as measles, whooping cough and scarlet fever, in addition to diarrhoea and other water-borne diseases, that had previously placed a heavy mortality burden on children post-weaning (Dyson, 2010, Preston and Nelson, 1974). In the mid-nineteenth century, over half of deaths in England and Wales resulted from infectious diseases, but by 1930 this had reduced to around a quarter of deaths (Omran, 1971). This dramatic fall in the importance of infectious diseases, and the fall in the overall death rate which resulted from it, was termed the ‘epidemiological transition’ by Omran (Bhopal, 2016, Omran, 1971).

The relative significance of various causes of this secular fall in the death rate, first seen in the countries of northern Europe and north America (Dyson, 2010), are subject to debate. The importance of public health interventions to provide clean water and treat sewage are considered key by some researchers (e.g. Costa and Kahn, 2015, Kesztenbaum and Rosenthal, 2017, Szreter, 1999). Piped

water from a high-quality source is noted as important for reducing waterborne diseases, especially typhoid (Davenport et al., 2019). Others stress the importance of better nutrition, with McKeown claiming that most of the fall in the death rate was due to improved diet (McKeown, 1976, McKeown and Record, 1962), although more recent research suggests that only around half of the improvement between 1830 and 1930 can be attributed to better nutrition (Fogel, 1997). The legal requirement for the notification of various infectious diseases enabled quarantine to be more effectively enforced, which also contributed to a lower death rate from infectious diseases (Szreter, 1988). The importance of education, which helped people to understand the role of hygiene in reducing mortality, is also cited by researchers (e.g. Kesztenbaum and Rosenthal, 2017, Murtin, 2013). The acceptance of the germ theory of diseases in the 1880s led to pasteurisation of milk and changes in food handling which increased food safety (Cutler et al., 2006). Apart from the introduction of the smallpox vaccine, medical treatment appears to have contributed relatively little to the decline in mortality prior to the early 1900s (Checkland and Lamb, 1982, Preston and Van De Walle, 1978).

There were marked spatial variations in the timing of the epidemiological transition, a central part of the mortality transition. These variations have been observed between countries (Santosa et al., 2014), and also within the same country, such as different regions of the Netherlands (Wolleswinkel-van den Bosch, 1998) or different *départements* (counties) in France (Bonnet and d'Albis, 2020). Differences in mortality levels and timing of the transition have also been seen between urban and rural areas (e.g. Cain et al., 2016, Woods and Hinde, 1987). Other work focussing on spatial differences in infant and early childhood mortality has been undertaken for England and Wales using registration district and sub-registration district data, which suggests that there were persistent spatial variations in the timing of falls in these mortality rates between 1881 and 1911 (Jaadla and Reid, 2017). Less work has been published on changing mortality inequalities within cities, the exceptions being Paris (Kesztenbaum and

Rosenthal, 2016, Kesztenbaum and Rosenthal, 2017) and New York/Philadelphia (Costa and Kahn, 2015)[7].

It is clear that some countries, or areas within them, benefitted from the mortality transition earlier than others, but there is less consensus on whether the mortality transition narrowed the gap between high and low mortality areas or not: that is whether there was convergence in mortality rates in the period. In Paris, between 1880 and 1940, although overall the death rate fell, there was initially divergence between areas, with the absolute gap in life expectancy between the top and bottom deciles increasing from around 8 years in 1880 to around 9 in 1910; this was followed by partial convergence with the gap falling to around 7 by 1940 (Kesztenbaum and Rosenthal, 2016). In the cities of New York and Philadelphia from 1900 to 1930, there was convergence in the death rate between poorer and better off wards with respect to certain infectious diseases[8], but the overall death rate did not converge much if at all (Costa and Kahn, 2015)[9]. Despite decreases in the average mortality rates in Stockholm 1878-1926, there was no evidence of a fall in the relative differences between socioeconomic groups (Molitoris and Dribe, 2016). With regard to infant mortality in the United States, there was divergence between social classes (defined by the occupation of the father) from 1890-1920, convergence from 1930s to the 1950s, and then divergence (Haines, 2011). Contrary findings are, however, shown by other researchers. For example, small-area differentials in infant mortality across England and Wales from 1890 declined consistently until the 1950s (Congdon et al., 2001). Again looking at infant mortality rate, Pamuk found that inequality decreased in absolute terms from 1921 to 1971, but that there was a relative increase in inequality from 1931 onwards (Pamuk 1985). An examination of mortality over a long period in France found inequalities in life expectancy between *départements* (counties) narrowed over the whole period from 1880 to 1980, except during the two world wars (Bonnet and d'Albis, 2020). Again, looking at differences between large areas rather than small area

[7] There has also been work on childhood mortality, but not overall mortality, for example in Toronto (Mercier, 2006) and Montreal (Thornton and Olson, 2011).
[8] These diseases were typhoid, diphtheria, diarrhoea, measles, scarlet fever, tuberculosis and pneumonia.
[9] The authors do not discuss why there was a difference in convergence between the infectious diseases death rate and the overall death rate, but do point out that in 1900 deaths from infectious diseases only accounted for around 35% of total deaths.

differentials, a convergence in overall life expectancy between US states was found to take place from the early 1900s to around 1960, after which time convergence stalled (Peltzman, 2009). A study of adult mortality differentials in two provinces in the Netherland, 1812-1922, found that there was convergence between members of different social classes across the period (Van Poppel et al., 2009).

Divergence, where it is seen, is ascribed to higher socioeconomic areas gaining earlier access to health benefits than lower socioeconomic areas (e.g. Kesztenbaum and Rosenthal, 2016) and convergence from 1930 onwards to narrowing income inequalities (e.g. Haines, 2011). Those who see a long-term narrowing of mortality inequalities point to increasing levels of social support over the first half of the twentieth century, and the reduction in the urban mortality penalty, both of which impacted particularly on the young (e.g. Congdon et al., 2001). The importance of falls in infant mortality for the long-term narrowing of mortality differentials is also noted in the study of French *départements,* although reasons why this should be the case are not discussed (Bonnet and d'Albis, 2020).

3.3 Health interventions in the two cities

3.3.1 Municipal Glasgow

The death rate in Glasgow in the early part of the nineteenth century averaged around 30-35 per thousand population, but was as high as 46 per thousand in years with particularly high disease outbreaks (Cowan, 1840). Concern around these mortality rates led to a number of actions by the municipal authorities, including the appointment of the city's first Medical Officer of Health, William Gairdner, in 1863, far in advance of when such a post was legally required in 1892 (1892). My analysis of these early reports suggests that the task of the Medical Officer of Health was initially to understand where the areas with the highest death rates were located and what characterised these areas. This is the focus of the early reports (Gairdner, 1863, Gairdner, 1864) which consisted mostly of discussion while highlighting some individual areas. Gradually the reports began to include systematic data on mortality, population density and persons per house for all areas of the city, now divided into sanitary districts,

allowing the development of policy recommendations aimed at specific districts. Gairdner was influential in establishing the City Improvement Trust in 1866, which sought to demolish over-crowded slum dwellings and replace them with more sanitary accommodation. To address the frequent outbreaks of deadly diseases such as cholera, smallpox and typhoid, a temporary 'fever hospital' was opened in 1865, and Belvidere Hospital, a purpose-build infectious diseases hospital, was opened in 1877. As a result of the imposition of the legal requirement to notify the authorities of certain infectious diseases (1890), the hospitalisation of the sick and the quarantining of their contacts could more easily be imposed.

A number of specific public health interventions were also undertaken by the City of Glasgow in order to address the high mortality rates. Although Glasgow was often thought of as a forward-thinking city and even accused of 'municipal socialism' due to the level of the council's involvement in public health and other matters (Fraser and Maver, 1996), these changes did not arrive without opposition. Many were debated at length, with concerns about the cost to the ratepayer (or to private landlords, who were influential on the council) often used to reduce or delay their introductions (e.g. Checkland and Lamb, 1982, Robertson, 1998). Indeed, Gairdner's post as Medical Officer of Health was rescinded in 1872, due in part to concerns about the implications of his enquiries for landlords and property owners, although he was replaced by James Burn Russell as the city's first full-time Medical Officer of Health a few months later (Checkland and Lamb, 1982).

The first major public health intervention by the municipal authorities was the provision of clean, piped water from Loch Katrine in 1859, although the provision of piped water by the municipality had been mooted as early as 1819 (Fraser and Maver, 1996, p454). The eventual introduction followed the highest recorded death rates for individual years which were 1832, when Glasgow experienced its first outbreak of cholera and 1837. Figure 3-1 shows changes in the observed death rate in Glasgow and the timing of a number of actions taken by the authorities to improve public health. The very high death rates in the 1830s were caused by outbreaks of cholera (1832) and typhus (1837-8) (Lees, 1996). The mandatory provision of indoor piped water was enforced in 1865,

with private landlords encouraged to co-operate by an abatement of the property taxes on low-cost housing (Glasgow Town Council, 1865). It should be noted, however, that 'indoor' in poorer tenements may have meant a communal sink on a landing to serve four or more houses (Glasgow City Council, 1996). Another early intervention was the legal provision for the municipality to remove middens[10] and force buildings to connect to sewers, which was introduced by the Glasgow Police Act 1866 (1866b). Both of these interventions occurred prior to the secular fall in the death rate and may be considered a necessary precondition (Wolleswinkel-van den Bosch et al., 1997). Actions by municipal authorities such as the provision of clean water and provision of sewers have long been associated in the literature with the fall in the death rate in large cities (e.g. Dyson, 2010, Szreter, 1988). Sewage was, however, deposited untreated into the river Clyde and other waterways. Mandatory provision of indoor water closets was enforced in 1890 (1890), but this often meant one water closet to be shared by four houses, each of which had four or five occupants (Glasgow City Council, 1996). The treatment of sewage was only introduced in 1894, and the entire city was not covered by comprehensive sewage treatment until 1910 (Glasgow Corporation, 1914).

In addition to the public health interventions seen in Figure 3-1, other changes to legal regulations in Glasgow are likely to have had a positive impact on mortality rates. A 'ticketing' system was introduced in 1862 which required dwellings to provide at least 300 cubic feet per person over eight years of age, and by the 1880s over 23,000 houses had had 'tickets' imposed on them (Cage, 1987). The City Improvement Trust was set up by the Glasgow Improvement Act 1866 (1866a) but increases in property taxes to fund it resulted in the then provost being voted out of office and the activities of the Trust delayed by at least ten years (Bell and Paton, 1896, Fraser and Maver, 1996). Eventually the Trust undertook the demolition of 16,000 substandard houses from the mid-1870s to 1914 (Fraser and Maver, 1996). New building regulations were also introduced which required streets to be as wide as the height of the tenements

[10] Midden is an old term for a rubbish heap which at this period in Glasgow would include food waste and human excrement.

which lined them (Anderson, 1892), resulting in wider streets and the improved ventilation of dwellings (Robertson, 1998).

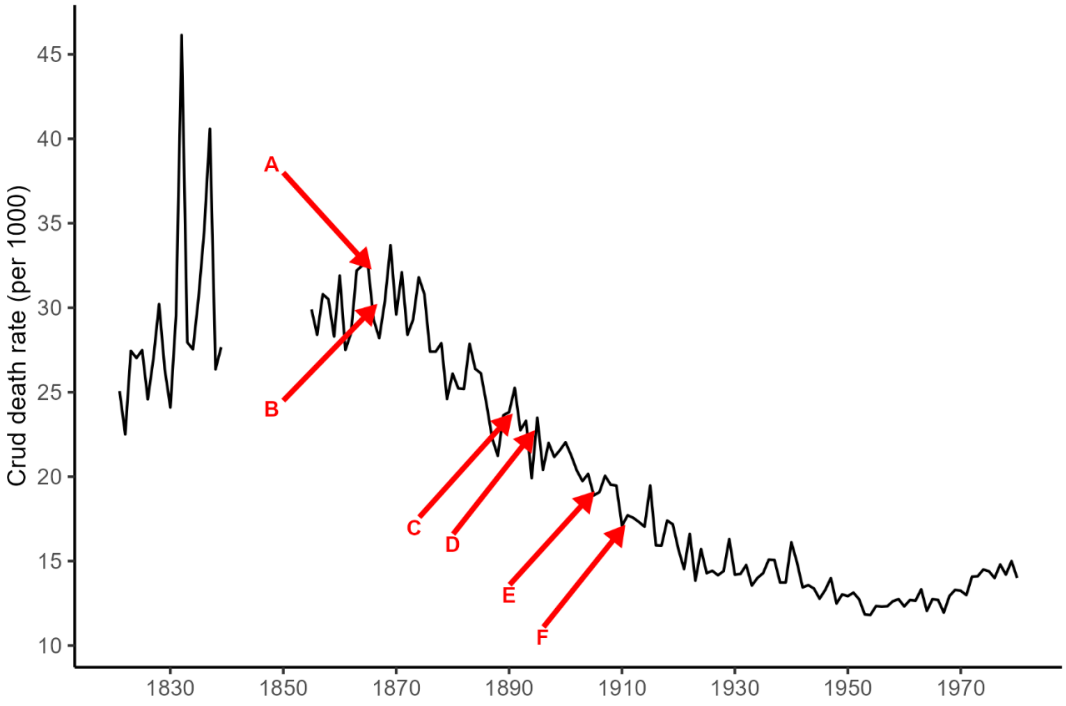


Figure 3-1. **Crude death rate in Glasgow from 1820-1980**
For years where data are available. A – 1865, indoor piped water is mandatory; B – 1866, Glasgow municipality can legally clear middens and force sewer connection; C – 1890, 'adequate' indoor provision of water closets is mandatory; D – 1894, first sewage treatment plant opens in Dalmarnock (for north of Clyde); E – 1904, sewage treatment plant opens at Dalmuir (for Partick and further west); F – 1910, sewage treatment plant opens at Shieldhall (for south of Clyde).

3.3.2 Municipal Manchester

Death rates in Manchester in the early part of the nineteenth century were very similar to those of Glasgow, averaging around 30-35 per thousand population but rising to over 40 per thousand in particularly bad years (e.g. Registrar-General, 1849, Registrar-General, 1852). One of the earliest public health interventions in Manchester was the piping of clean water from the Peak District in 1852, and this was followed by the gradual introduction of piped water indoors, so that over 80% of the population had access to this by the 1870s (Hassan, 1984). Due to the continued high demand for water, Thirlmere in the Lake District was acquired by the city in the 1870s, but this new scheme provoked significant opposition and only opened in 1894 (Tatham, 1894, Wohl, 1983). Underground sewers were laid across the city between 1830 and 1860, but as in Glasgow the waste was deposited untreated into waterways. The first Medical Officer of

Health was appointed in 1868 (Leigh, 1871). Manchester had its own act enforcing the notification of infectious diseases in 1881 (1881), eight years earlier than the national Infectious Disease (Notification) Act of 1889 (1889). This meant that quarantine measures could be systematically imposed in Manchester from this date (Leigh, 1883). In contrast to Glasgow, however, the city did not have its own infectious diseases hospital and relied on paying the Manchester Royal Infirmary to provide an infectious diseases service (Wohl, 1983, p139). The provision of indoor water closets in new dwellings became mandatory in 1881 but these were not required in all buildings until 1892 (Wohl, 1983). Figure 3-2 shows changes in the observed death rate in Manchester and the timing of certain public health interventions.

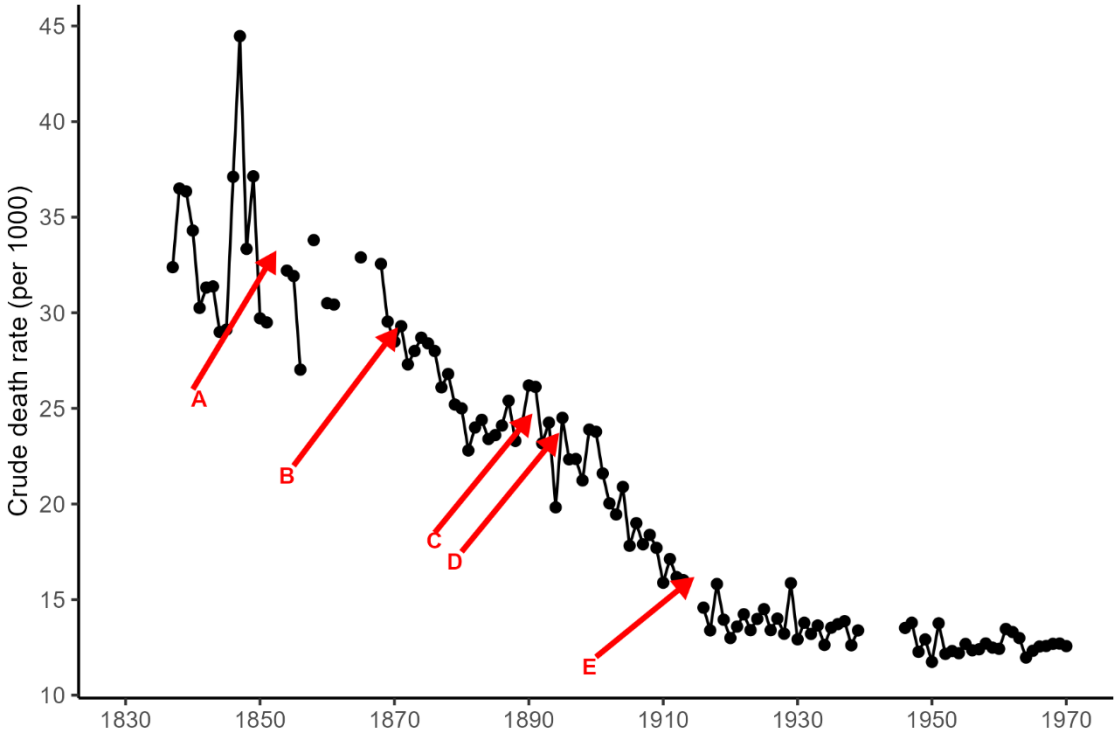


Figure 3-2. Crude death rate in Manchester from 1830-1970
For years where data are available. A – 1852, date when piped water was supplied from Peak District; B – 1870, the majority (around 80%) of households now have piped indoor water; C – 1892, indoor plumbing mandatory in all buildings; D – 1894, first sewage treatment plant opened at Davyhulme. Solid waste separated out and spread on fields; E – 1914, Davyhulme treatment plant upgraded to sludge.

Manchester's first city improvement scheme, involving the demolition of the worst slums, only started in 1891, far later than in many major cities including Glasgow where the City Improvement Trust began its work in the 1870s. Manchester Corporation delayed involvement in housing matters due to the

objections of ratepayers and the belief that commercial interests would eventually meet housing needs (Wohl, 1983). After much debate around costs, the first treatment of sewage was introduced in 1894, with comprehensive sewage treatment for the entire city being achieved in 1914. The failure to provide a proper sewage system backed up by sufficient water closets was blamed by the Medical Officer of Health for the high incidence of diseases such as diarrhoea in working class areas as late as 1911 (Redford, 1939).

There were many parallels between Glasgow and Manchester as they passed through the mortality transition, despite being located around 220 miles apart and subject to separate legal jurisdictions (Scotland for Glasgow, and England and Wales for Manchester). Both cities grew rapidly during the nineteenth century and both were industrial centres which provided employment for large numbers of people drawn in from other areas, but did not initially provide the infrastructure to support this influx. Both cities suffered epidemics of infectious diseases, with frequent outbreaks of cholera and typhus which led to death rates as high as 46 per thousand in Glasgow (1832) and 44 per thousand in Manchester (1847). The death rate in both cities began a secular fall from around 1870, which followed the provision of piped water within the majority of the cities' homes. The similarity between the observed crude death rates of the two cities is noticeable, as can be seen from comparing Figure 3-1 and Figure 3-2. The two cities took slightly differing approaches to the introduction of public health measures, as can be seen in Table 3-1.

Table 3-1. Comparison of public health interventions in Glasgow and Manchester

Public health intervention	Glasgow	Manchester
Provision of clean piped water	1859	1852
Majority of houses now have clean piped water	1865	1870
Forced clearance of middens	1866	-
Appointment of first Medical Officer of Health	1863	1868
Introduction of 'improvement areas' (demolition of slums, etc.)	1875	1891
Enforced notification of infectious diseases	1889	1881
Requirement for indoor water closets	1890	1892
First sewage treatment plant opened	1894	1894
Sewage treatment covers whole city	1910	1914

There is remarkable consistency between the cities in the introduction of some measures such as clean piped water (1852 in Manchester and 1859 in Glasgow) and the opening of sewage plants (1894 in both cities). In other areas, there was

more discrepancy with Glasgow enforcing the clearance of middens in 1866 while there was no comparator legislation in Manchester, although a move to pail middens was encouraged. Glasgow also introduced a systematic approach the slum clearance significantly earlier than Manchester (1875 as opposed to 1891).

3.4 Sigmoid mortality dynamics

The mortality transition in the UK took place from around 1850 to around 1950. It is necessary to plot death rate data over a sufficiently long period of time for the transition to become apparent. The observed data reveal a pattern of high initial death rates, followed by falling rates and ending with a period of sustained low death rates. It is useful to fit a trend to this data to remove annual variations and identify the pattern of the fall. Fluctuations in the death rate in the late nineteenth and early twentieth centuries were caused by asynchronous outbreaks of infectious diseases such as scarlet fever, measles and whooping cough, and such outbreaks can at times mask the downward trend in mortality (see Figure 3-1 and Figure 3-2).

A sigmoid function can be used to model the pattern of the fall in the death rate, as illustrated in Figure 3-3. In particular, I assume that the trend death rate evolves over time following a logistic curve, specified as a four-parameter logistic function given by

$$d_t^i = \delta_l^i + \frac{\delta_u^i - \delta_l^i}{1+e^{(\beta^i(t-\tau_c^i))}} \qquad [2]$$

where d_t^i is the trend crude death rate for area *i* at time *t*, δ_u^i is the upper asymptote of the trend death rate, δ_l^i is the lower asymptote of the trend death rate, β^i determines the slope at the inflection point (maximum slope) and τ_c^i is the inflection year. This model is applied separately to each area studied. The upper asymptote of d_t^i is the upper value that d_t^i tends towards prior to the sample, and the lower asymptote is the lower value that d_t^i tends towards after the sample. The slope at the inflection point is the slope where d_t^i changes convexity, and the inflection year marks the date when this happens. The trend

death rate falls slowly initially, and then more rapidly until the inflection year, after which the rate of decline slows until a new steady state is reached[11]. The drda (Dose Response Data Analysis) package in R is used to fit the logistic model to my data (Malyutina et al., 2021).

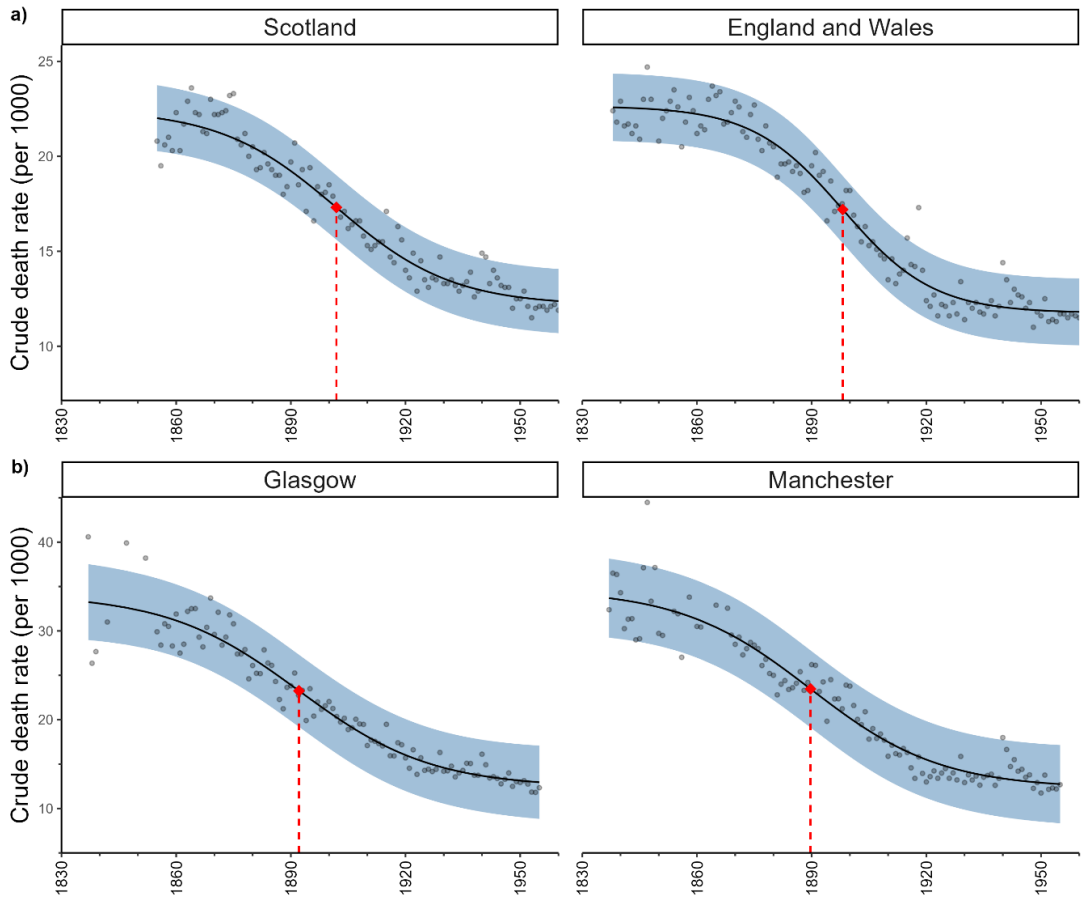


Figure 3-3. Death rate for countries and cities
Observed crude death rate shown by grey dots and fitted 4-parameter logistic trend death rate shown by black line given by [2]., The inflection year shown by dashed red line and the 95% prediction interval shown by the blue ribbon. a) Scotland, 1855-1955 and England, 1837-1955; b) Glasgow and Manchester, 1837-1955.

The logistic model provides a good fit to the mortality data at country and city level, with almost all points being within the 95% prediction interval. Those points outside the 95% band are either in the very early years of the period when fluctuations in the death rate were most severe, or in the World War years when mortality was again atypical. The mortality transition can be clearly seen in Figure 3-3a) for Scotland, 1855-1955, and England and Wales, 1837-1955. The rate of fall is not constant over the period, beginning slowly and then falling at

[11] For more details on this estimation see our joint paper Angelopoulos et al (Angelopoulos et al., 2024).

an increasing rate. The plots of the two countries show a remarkable level of similarity, with inflection points only three years apart: 1901 in Scotland and 1898 in England and Wales. After this date, the fall in the death rate slows, and by 1955 the trend line is almost flat, showing that the countries have passed through the mortality transition and are settling at a new, low mortality level.

A similar pattern to that at the country level is seen with the death rate of the two cities, Glasgow and Manchester (Figure 3-3b). These data series both begin in 1838, and again follow a sigmoid shape. Both cities start with a higher death rate than the countries, as we would expect from the literature highlighting the higher mortality experienced in cities (e.g. Cain et al., 2016, Dyson, 2010). It is only after the First World War that observed death rates at the city level draw close to the country averages. The inflection years for the cities are even closer than those for the countries, being 1892 for Glasgow and 1890 for Manchester. The inflection years occur earlier in the cities than in the countries, with the high initial city mortality falling rapidly, probably in response to the public health and other interventions that were discussed in Section 3.3. These interventions were implemented in large cities such as Glasgow and Manchester in response to the exceptionally high death rates seen in urban as opposed to rural areas (Haines, 2011, Szreter and Mooney, 1998); there was less urgency for interventions in rural areas. Figure 3-3 shows that in the 1850s, there was a large difference between the death rates in Glasgow and Manchester (around 32 per 1000) and those of the corresponding nations (around 22), giving clear evidence of what has been termed the 'urban mortality penalty' (e.g. Cain et al., 2016). However, by the end of the period, the trend crude death rates for the cities (Glasgow 13, Manchester 12.7) were very similar to those for the countries (Scotland 12.7, England and Wales 11.8). These data for the countries and cities confirm the findings of other researchers that the mortality transition within the United Kingdom was completed by around the middle of the twentieth century (e.g. Dyson, 2010) and that the urban morality penalty had, by that time, largely disappeared (e.g. Haines, 2011).

As a robustness check to modelling the trend death rate using a logistic function, I fitted an agnostic loess curve to the data. The loess model was selected as it is a very flexible, non-parametric model that is commonly used to smooth volatile

time series (Cleveland, 1979, Cleveland et al., 2017)[12]. The logistic trends from Figure 3-3 have been plotted against the loess trends and are so similar that often the lines cannot be told apart (Figure 3-4). This confirms that the logistic trend is a good fit for the data; in the remainder of this chapter it is used in all cases where the data permit such a curve to be fitted. The advantage of using the logistic function over, for example, the loess is that it provides interpretable parameters such as the inflection year and the slope at the inflection point.

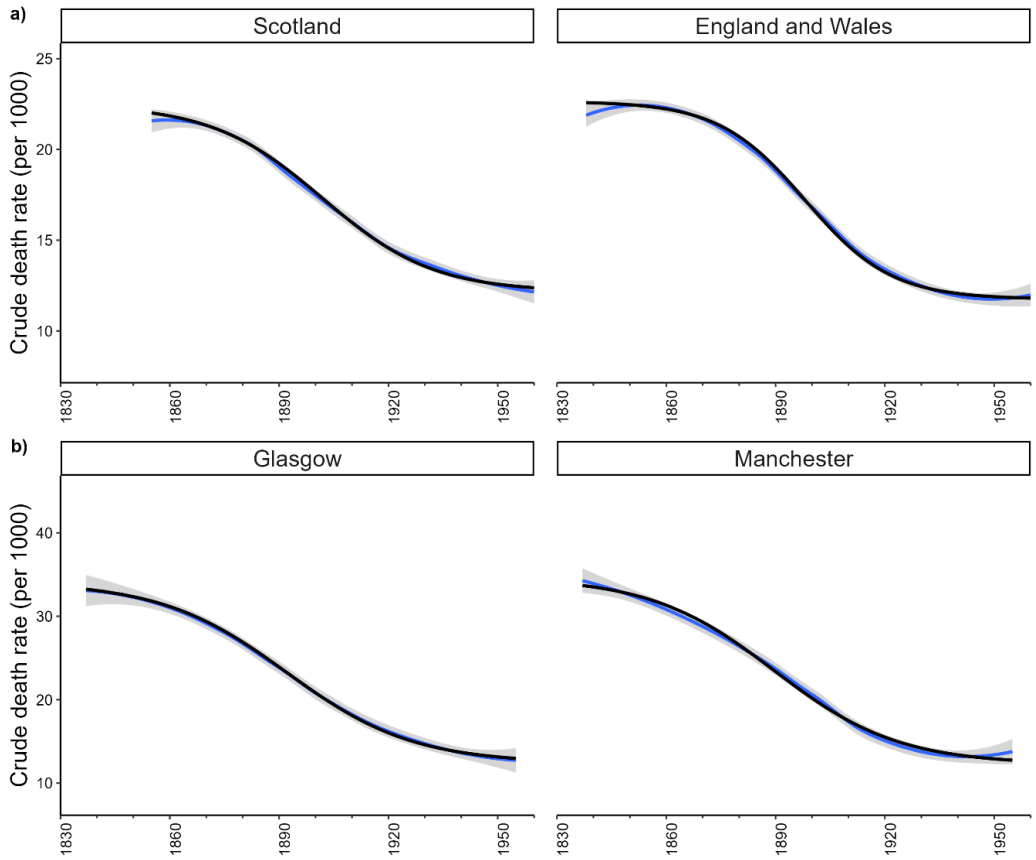


Figure 3-4. Comparison of loess curve and fitted 4-parameter logistic trend death rate. Loess curve fitted to observed crude death rate (blue line) and fitted 4-parameter logistic trend DR (black line), with the 95% prediction interval of the loess curve shown by the grey ribbon. a) Scotland, 1855-1955 and England and Wales 1837-1955; b) Glasgow and Manchester, 1837-1955.

A possible explanation for why the fall in the death rate exhibits this sigmoid pattern is the variation in the timing of the adoption of technologies that improved mortality, with relatively few, higher socioeconomic status individuals being initially able to benefit. We discuss this issue in other work (Angelopoulos et al., 2024), where we suggest the pattern is very similar to that predicted by the theory of the diffusion of innovations. This theory states that the proportion

[12] The Loess function uses a local polynomial regression fitting, which calculates the fit at each point *x* using points in the neighbourhood of *x*, using weighted least squares.

of adopters of technological innovations is determined by the economic incentives and constraints relating to the adoption of the new technology (Stokey, 2021). In general, early adopters face higher costs. Health technologies in the nineteenth century included access to plentiful clean water and water closets which allowed improved levels of hygiene, larger, well-ventilated homes and more plentiful and safer food as a result of, for example, pasteurisation. The distribution of income in the United Kingdom in the nineteenth century was very unequal, tending to have a long right-hand tail, meaning that the number of higher income individuals would be relatively small (e.g. Kuznets and Murphy, 1966, Lindert and Williamson, 1983). This means the number of adopters of the new technologies would initially be low. As the technologies developed, costs fell meaning that more people could afford to benefit. Increases in the average level of income, which happened in the latter half of the nineteenth century (e.g. Crafts and Mills, 2017, Sperber, 2009) would have a similar impact in making access to these benefits more affordable. Gradually the improvements in technology would impact on a larger proportion of the population, which resulted in a more rapid fall in the death rate: this is the period up to and around the inflection year. After the inflection year, the majority of the population had already adopted the new technologies so further health improvements have a smaller impact, such that the fall in the death rate slows. Even when new technologies are theoretically available to all, research suggests that the ability to benefit from them will still vary, dependent, for example, on whether knowledge diffusion has also taken place (Skare and Soriano, 2021).

3.5 Heterogeneity in the mortality transition in small areas

3.5.1 Heterogeneity in the mortality transition within Glasgow

Given my findings in Chapter 2, which show that mortality differentials are associated with initial socioeconomic conditions, it seems likely that these conditions will also matter for the dynamics of the mortality transition. The wards in Glasgow in the late nineteenth century showed a marked variation in socioeconomic conditions. Four possible measures of these conditions are available in my dataset: persons per room, rooms per dwelling, population

density and the illegitimate births as a percentage of all births. Variations in all of these were marked, with persons per room, a measure of overcrowding and income, being as high as 2.7 persons per room in some wards in the east end in 1891, compared to only 0.6 persons per room in Kelvinside. Higher socioeconomic conditions are indicated by lower persons per room (less overcrowding), a higher number of rooms per dwelling (larger house size), lower population density (an indication of more outside space and lower pollution levels) and lower rates of illegitimate births, which are used as a general proxy for socioeconomic conditions with which they are strongly correlated (e.g. Ventura, 1969). For example, the percentage of illegitimate births in 1898 was around 9% in wards such as Townhead, a central district, and Calton in the east end, but only 2% in the wealthier southern wards.

In order to understand the mortality dynamics of the individual Glasgow wards, I attempted to fit a logistic trend to the available data, which is 1878-1937 for 21 wards and 1891-1937 for the four wards which joined the city in 1891. The history of the expansion of the city is covered in full in Chapter 2. Mortality rates for the four wards which joined Glasgow in 1891 (Kelvinside, Pollokshields, Langside and Maryhill) do not permit the fitting of a logistic curve; see Figure 3-5. At the date these wards joined the city, they had significantly better socioeconomic conditions than the city average, and also lower mortality rates. As data are not available prior to these areas joining the city, I do not have a sufficiently long time series of data to enable the sigmoid shape of the mortality transition to become apparent. Trends in the available data have, instead, been highlighted by the fitting of a loess curve. Three of the wards, Kelvinside, Langside and Pollokshields, had death rates of around 10 per thousand population when they joined the city, suggesting that they had already passed through the mortality transition. Instead of remaining flat, as we might expect, the crude death rates started to rise after 1900. This may be due to the socioeconomic mix of these areas changing, likely as a result of migration of poorer families to these areas as the city expanded: my data show that the average house sizes fell and the number of persons per room increased in these wards. Maryhill is the exception among these wards in that it had not completed the mortality transition before it joined the city, with the crude death rate being around 20 in the 1890s and only falling to around 10 in the 1920s. Figure

3-5 probably shows the end of its mortality transition; we are not able to see the earlier part of the process due to the lack of administrative records prior to 1891.

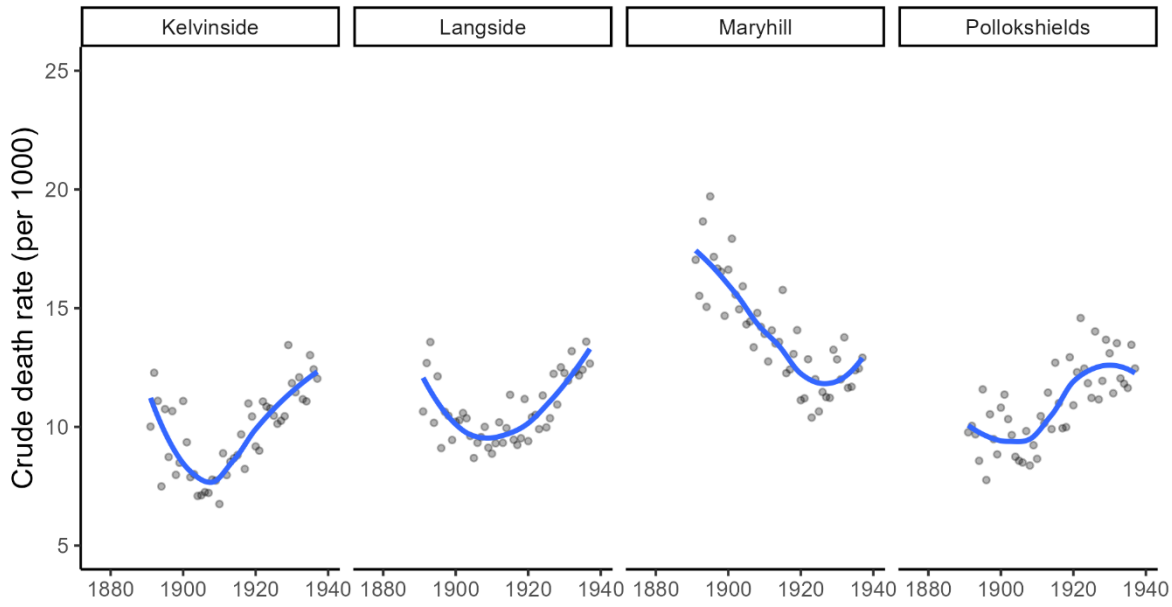


Figure 3-5. Death rate for wards which joined Glasgow in 1891
Crude death rate (grey dots) and loess curve fitted to crude death rate (blue line), 1891-1937.

For the majority of the other wards in Glasgow, the small area mortality data can be modelled by the logistic function, and we see that the mortality transition happened far earlier in some areas than in others. Figure 3-6 shows the observed death rates with a logistic curve fitted for six illustrative wards. Figure 3-6a) shows wards with higher socioeconomic conditions and Figure 3-6b) wards with lower socioeconomic conditions. Illegitimate births as a proportion of all births is shown in the bottom left corner of each plot. Lower proportions of illegitimate births have been shown to be correlated with higher socioeconomic conditions and vice versa (Koops et al., 2021, Modin et al., 2009, Ventura, 1969). The wards with better socioeconomic conditions start with a trend death rate of below 25 per thousand and have an inflection year before 1900. Wards with poorer socioeconomic conditions start the period with a trend death rate over 25 and have an inflection year after 1900. Within the city of Glasgow, we therefore see that wards with higher socioeconomic conditions not only had lower mortality levels at the start of the period but also passed through the mortality transition earlier. The gap between inflection years is 13 years between Woodside (1897) and Cowcaddens (1910). This pattern is the opposite of that

seen in comparisons between cities and their respective country averages, which showed the high-mortality cities moved faster into the mortality transition than countries.

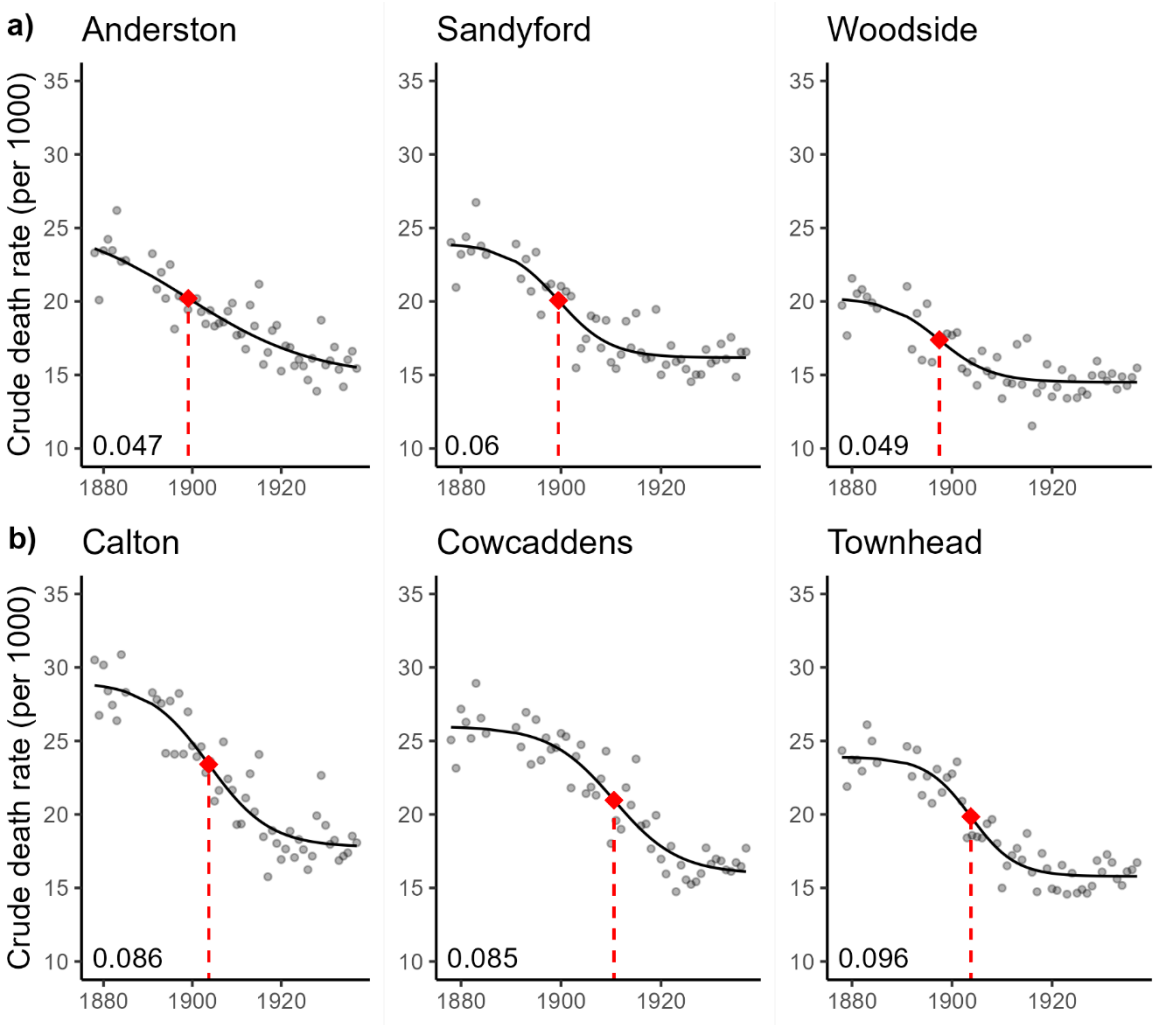


Figure 3-6. Death rate in selected Glasgow wards 1878-1937
Observed crude death rate (grey dots) and fitted 4-parameter logistic trend death rate (black line), with inflection year shown by dashed red line and illegitimate births as a proportion of all births 1898 shown in bottom left corner of each plot. a) Wards with higher socioeconomic conditions, with an inflection year before 1900; b) Wards with lower socioeconomic conditions, with an inflection year after 1900.

Within Glasgow, it was wards which already had the lowest death rates that profited first from the mortality transition. In Chapter 2, I showed that the mortality penalty and average end-of-period death rates were closely associated with a ward's initial socioeconomic position. We now see that the dynamics of the mortality transition are also influenced by initial socioeconomic conditions, so that those with greater resources gained mortality benefits first. These benefits are likely to have arisen from better access to factors which impacted on health such as more space per person, plentiful piped water, indoor water

closets, better education and improved nutrition. Because these wards with better socioeconomic conditions saw both earlier and more rapid falls in the death rate, they pulled away in mortality terms from the wards which had, on average, a poorer socioeconomic situation.

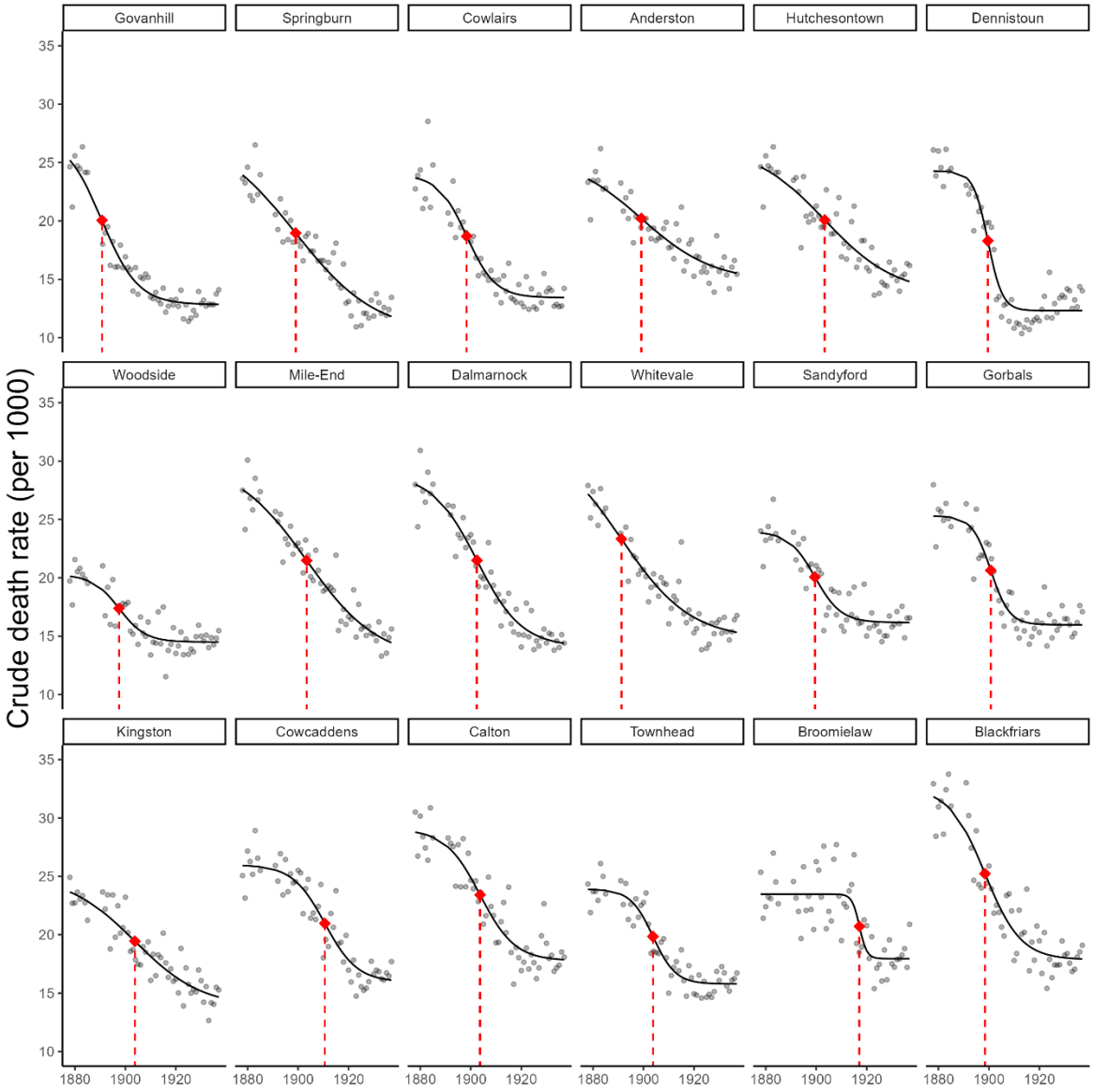


Figure 3-7. Fitted 4-parameter logistic trend death rate, Glasgow 1878-1937.
Observed crude death rate (grey dots) and fitted 4-parameter logistic trend death rate (black line), with inflection year shown by dotted red line, for 18 wards that show a logistic trend, ordered by percent illegitimate births (lowest first).

This pattern seen in the six example wards is confirmed when we examine plots for a larger number of wards (Figure 3-7). A logistic trend can be fitted for 18 of

the 21 Glasgow wards for which I have data going back as far as 1878[13]. In this figure, the wards have been ordered (top left to bottom right) by socioeconomic conditions, as indicated by illegitimate births as a proportion of all births. The inflection year is generally, although not always, earlier for the wards in the top row than in the bottom row. This provides a visual indication of the variation in mortality dynamics between wards.

Socioeconomic conditions are shown to be linked to both the inflection year and the slope at the inflection point in our other work on this topic, where we create a statistical model to test the relationship (Angelopoulos et al., 2024). As with the models I used in Chapter 2, this model uses socioeconomic indicators from the final decades of the nineteenth century, i.e. prior to the change in convexity of the logistic curve (given by the inflection year) which tends to be around 1900. The impact of socioeconomic conditions on the inflection year is statistically significant and has the expected sign, meaning that higher socioeconomic conditions are associated with an earlier inflection year.

There are a further three Glasgow wards where the available data are not described by the sigmoid function, see Figure 3-8. These were all wards in or close to the centre of the city. As discussed in Chapter 2, Exchange is the most central of these and by 1900 was an area made up mostly of business premises, with a small resident population. Blythswood had been a very desirable area to live in the mid-1800s, but by 1900 had also become a commercial area with relatively few residents. Both Exchange and Blythswood had under three thousand residents by 1937, a stark contrast to the average population for the 25 wards, which was 31,000. It is likely that the reason we are not seeing the mortality transition modelled by a logistic function in these wards is because of their small (and falling) populations and the atypical land usage. Park was less central and saw less business development during this period, instead seeing an increase in both the number of residents and of houses. Over the period the average house size fell and the number of persons per room increased, suggesting that the reason we are not seeing the mortality transition here is that

[13] The boundary changes for Govanhill over this period mean the death rate figures for the early years may not be fully consistent with those in the years after 1891.

Park saw a change in the socioeconomic mix of residents similar to that seen in Kelvinside, as discussed above.

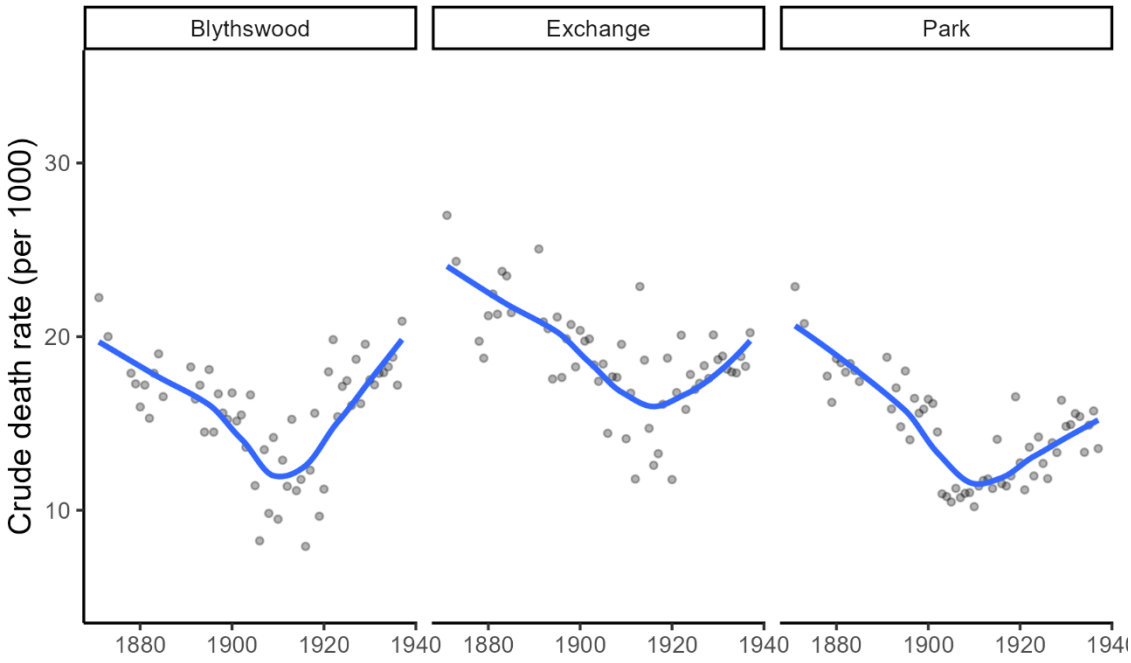


Figure 3-8. Death rate for Glasgow wards not shown elsewhere, 1878-37
Observed crude death rate (grey dots) and loess curve fitted to crude death rate (blue line).

There is a clear and frequently commented upon difference in the death rate in the various small areas of Glasgow, going back to the nineteenth century (e.g. Gairdner, 1864) and continuing to recent times (e.g. Walsh et al., 2016). This difference can be clearly seen as the city passed through the mortality transition, from the 1870s onwards, with some wards starting with mortality rates over 30 per thousand population, while others were around 20 per thousand. The plots above show that, in the majority of wards, the pattern of the falling death rate followed a sigmoid shape, and that wards with higher socioeconomic conditions generally underwent the transition sooner. These conclusions are in line with findings of other researchers (e.g. Kesztenbaum and Rosenthal, 2016, Mackenbach, 2012), who find that areas with higher socioeconomic conditions benefitted first from falling mortality rates. My findings provide additional insight into the pattern of the fall in the death rate and the difference in the way wards experienced this fall, with higher socioeconomic circumstances being associated with not just earlier but also, at that stage, faster falls than wards with lower socioeconomic circumstances. Even in 1937, the impact of socioeconomic conditions in the 1890s is still being

felt, with lower socioeconomic wards not (yet) attaining very low death rates. The relationship between initial socioeconomic conditions and the dynamics of the mortality transition has important implications for policy makers, suggesting the long-lasting impact of socioeconomic inequalities, as discussed below.

3.5.2 Divergence and convergence of death rates: Glasgow

We have seen that death rates fell across most wards in Glasgow during the period of the mortality transition, but that significant inequalities remained between wards even at the end of the data series in 1937. In the literature review, I discussed that some researchers suggest there was convergence between the higher and lower death rate areas throughout this period (e.g. Congdon et al., 2001), while others suggest that there was, at least initially, divergence (e.g. Haines, 2011, Kesztenbaum and Rosenthal, 2016). Initial divergence would mean that the inequality in mortality rates seen in the late 1800s worsened before it improved, meaning that those areas which were already ahead of the city average pulled away still further.

The plots seen in Figure 3-6 and Figure 3-7 do indeed suggest that inequality increased in the early years of the mortality transition, before eventually falling. This is because the wards with higher socioeconomic status, such as Woodside and Sandyford, had an earlier inflection year. Note that the inflection year is the point of the change in convexity of the logistic function, indicating the most rapid fall (i.e. the point of maximum slope). This suggests that at this point these wards were accelerating away from the lower socioeconomic wards, which were still experiencing the initial phases of the transition where mortality falls were only modest. The timing of the change in convexity has important implications for the divergence or convergence of mortality rates between wards, with the earlier start being seen in higher socioeconomic wards who already had lower mortality.

To illustrate how the mortality gap widens and then narrows, the logistic curves of two wards only are plotted in Figure 3-9, from 1878 to 1937. Govanhill is a ward with relatively high socioeconomic conditions and Cowcaddens is a ward with some of the lowest socioeconomic conditions. The trend death rate in

Govanhill falls rapidly from the beginning of the period and reaches its maximum slope in the inflection year around 1891; thereafter the rate of decline slows. The Cowcaddens trend death rate falls only slowly until well after Govanhill's inflection year, increasing its speed of decline around 1900 and reaching maximum slope at its own inflection year in 1910. It can be seen that the gap between the two death rates increases for most of the early part of the period, meaning we have divergence between the wards. The maximum gap is reached in 1903, which is marked by the vertical red line. After 1903, the gap between these two wards narrows, so we are now seeing convergence. Convergence only happens during the period when the death rate in the higher mortality/lower socioeconomic areas falls more rapidly than in the lower mortality/higher socioeconomic areas.

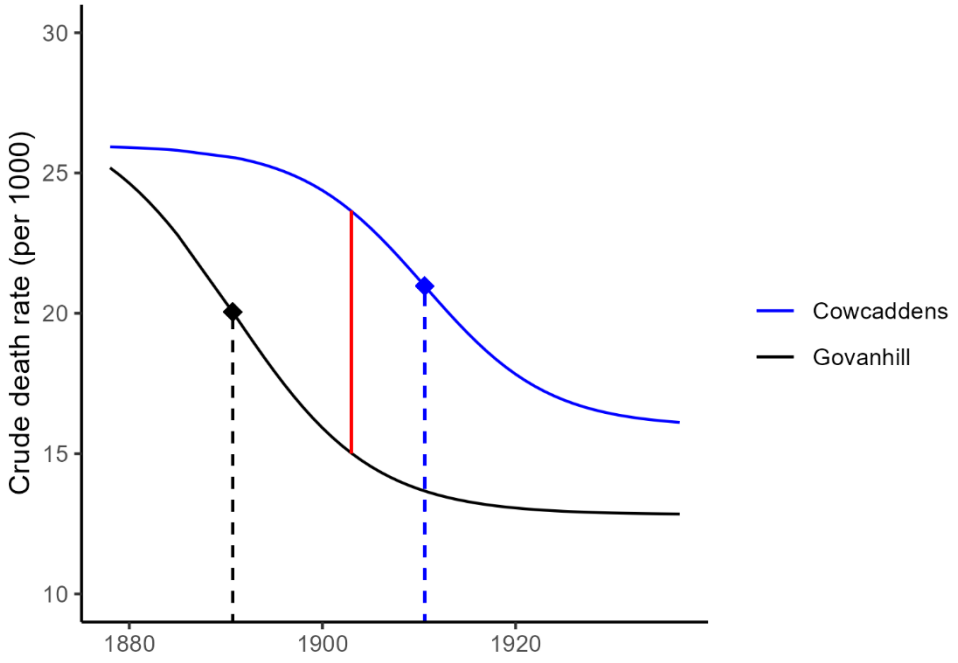


Figure 3-9. Fitted 4-parameter logistic trend death rate for two contrasting Glasgow wards. Govanhill (black line) and Cowcaddens (blue line), with inflection years shown by dotted lines, and the maximum gap between death rates by the solid red line.

An alternative way to examine whether we see divergence or convergence in Glasgow's mortality rates is to study the coefficient of variation in mortality across wards. The coefficient of variation is a measure of the level of dispersion around the mean, with a higher number indicating greater dispersion, i.e. greater inequality. The coefficient of variation of the death rate is illustrated for Glasgow wards in Figure 3-10 and considers groups of wards, not just two wards as were shown in the example in Figure 3-9. Figure 3-10a) includes the 21

wards which existed in the period 1878-1937, and it can be seen that at the start of the period the variation between wards was relatively low. Around 1900, the level of variation increased and it continued to be high until after the First World War, when it fell back to the lowest levels seen over this time frame. Figure 3-10b) includes all 25 wards, but runs only from 1891 to 1937. Due to the addition of the newer, low mortality wards, in particular Kelvinside, Pollokshields and Langside, the coefficient of variation for this data series starts markedly higher. Nevertheless, the level of dispersion continues to increase until around the First World War, when it falls. These plots of the coefficient of variation tell the same story of divergence followed by convergence as was seen in the plots of the logistic function, with the lower death rate wards pulling away from those with a higher death rate in the 1890s and early 1900s, before the two groups draw closer together again in the 1920s. Thereafter convergence continues, although it is never complete.

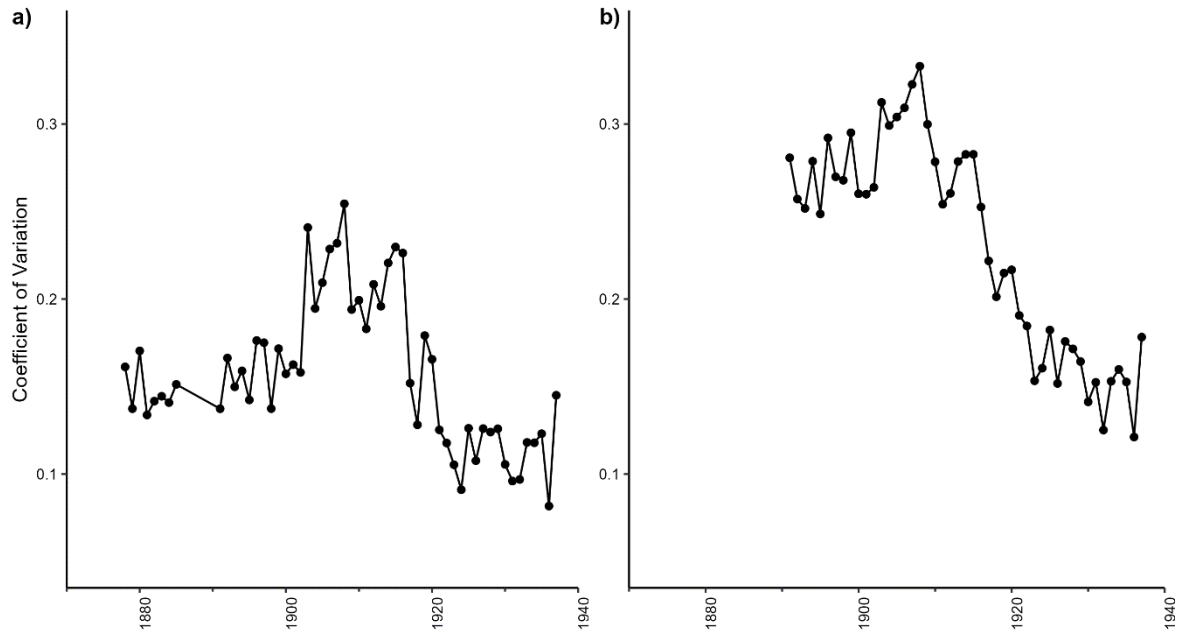


Figure 3-10. Coefficient of variation of crude death rates in Glasgow
Black dots showing individual years: a) for 18 wards 1878-1937 and b) for 25 wards 1891-1937.

I conclude that prior to the First World War there was divergence between Glasgow wards with respect to mortality, this being demonstrated both in the logistic functions fitted to the observed death rate and when examining the coefficient of variation. This divergence was due to the prolonged higher mortality levels in the wards where lower socioeconomic conditions delayed the fall in the death rate. Significant convergence only happened from around 1920,

which was when enough of these wards had undergone the mortality transition and were attaining a new, lower death rate. I note that full convergence is not evidenced in this dataset meaning that significant mortality inequalities persist in 1937. Incomplete convergence is one of the predicted implications of a lack of full knowledge diffusion, for example unequal access to education (Skare and Soriano, 2021), and this may be what we are seeing here. My findings are in line with those of, for example, Kesztenbaum and Rosenthal who found the mortality gap between *arrondissements* in Paris (measured in their work by life expectancy) increased between 1880 and 1910, and then converged up to the end of their data series in 1940, but that significant inequalities remained (Kesztenbaum and Rosenthal, 2016). My findings differ from those of Costa and Kahn, who found no convergence in death rates in two American cities, 1900-1930 (Costa and Kahn, 2015).

3.5.3 Heterogeneity of the mortality transition within Manchester

Manchester also saw heterogeneity in the timing of the mortality transition between different small areas of the city, as far as can been seen from the data available. A data series at small area levels is available from 1891 to 1924 and shows the death rate varied between 17 and 34 per thousand in 1891 and between 10 and 23 in 1924; the death rate had fallen but nevertheless remained very high in some areas. The geography of the city and the relative socioeconomic position of the various statistical divisions are discussed in detail in Chapter 2.

The four-parameter logistic function [2] was used to model the pattern of the fall in the death rate and the results for six statistical divisions are shown in Figure 3-11. The plots are ordered by illegitimate births as a percentage of all births, which is a marker of socioeconomic conditions, and we would expect the top left-hand division (Blackley) to have the earliest inflection year and the bottom right (Clayton) to have the latest. However, no clear pattern is apparent, which is probably due to the short series of data available – 34 years compared to 47 years for some Glasgow wards. Given the short time series of data for Manchester, the logistic model of the trend was not very helpful; see Appendix 8.2.1, Figure 8-5 for plots of all 18 statistical divisions. As with some

Glasgow wards, it is clear that we do not have sufficient data to see the full mortality transition and these plots therefore present only a partial picture.

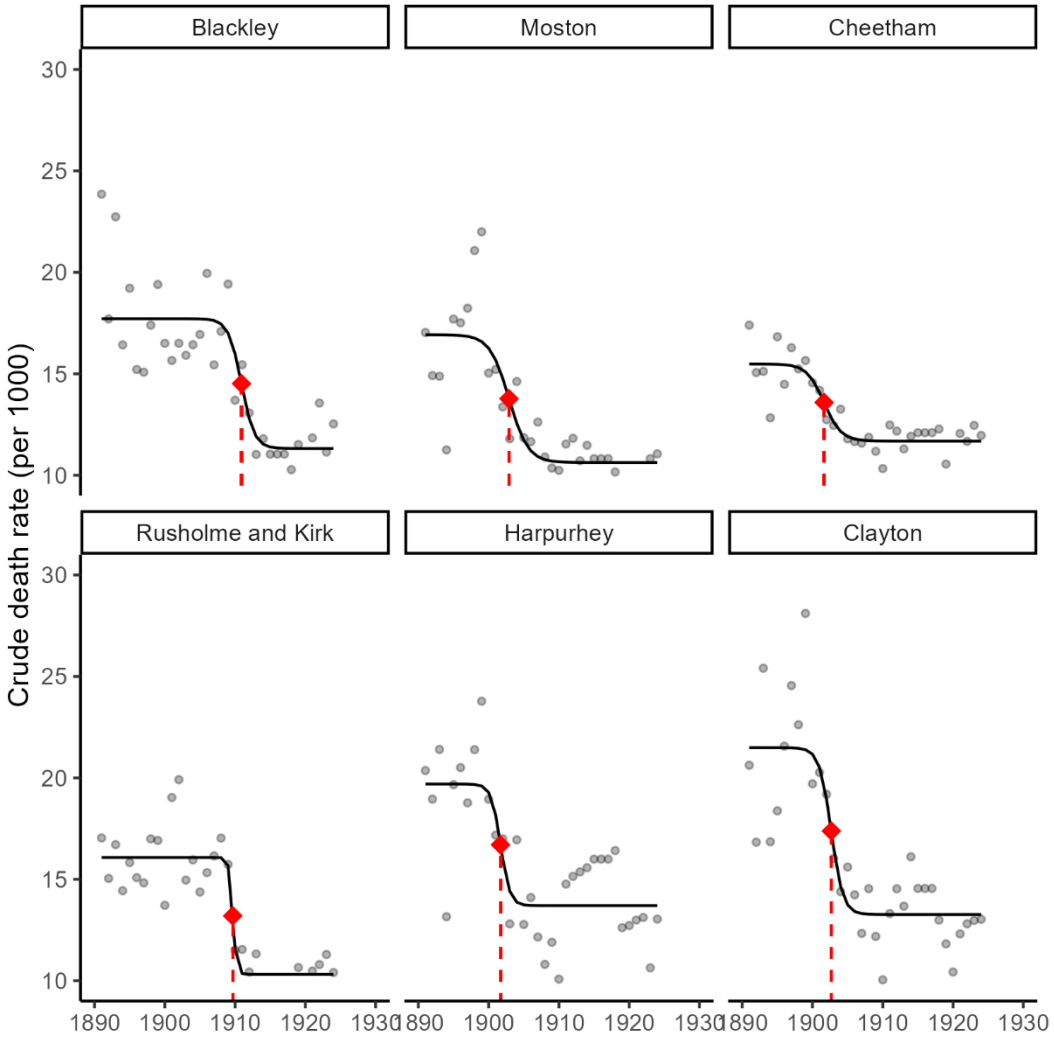


Figure 3-11. Death rate in selected Manchester statistical divisions, 1891-1924
Observed crude death rate (grey dots) and fitted 4-parameter logistic trend death rate (black line), with inflection year shown by dotted red line, ordered by percent illegitimate births (lowest first).

I conclude that it is not possible to use the logistic function to gain a clear picture of mortality transition dynamics for Manchester statistical divisions, as this is not a good fit for the available mortality data. This is not due to a lack of mortality transition in the small areas of this city, but due to the lack of a sufficiently long time series. When shorter time series were plotted for Glasgow, for all wards from 1891, this also resulted in fewer wards showing the sigmoid pattern of the fall in the death rate (Appendix 8.2.2, Figure 8-6). The importance of a long time series to allow the logistic function to be fitted is confirmed in our paper where we look at small area death rate trends in London: data from 1857 to 1936 make it possible to capture the earlier concave part of

the transition dynamics in the death rate in almost all areas (see Angelopoulos et al., 2024).

3.5.4 Divergence and convergence of death rates: Manchester

Analysis of divergence and/or convergence between the low mortality and high mortality districts of Manchester was also conducted. As seen in Section 3.5.3, it is not possible to examine this using logistic functions due to insufficient data, but plots of the coefficient of variation can be used to study dispersion. The output for Manchester statistical divisions is shown in Figure 3-12, using the same scales as the coefficient of variation plot for Glasgow (Figure 3-10) to facilitate comparison. The 18 statistical divisions for which we have data from 1891 are shown in Figure 3-12a) which shows a gradual increase in variation up to the First World War, after which time it falls. The same pattern is seen even if we include the relatively more affluent divisions that joined the city in 1905 and 1910 (Figure 3-12b). The addition of the more affluent divisions increased the amount of variation between areas (as did the addition of new wards in Glasgow in 1891) making the upward trend after 1905 more marked. It is nevertheless clear in both plots that mortality rates diverged at the end of the nineteenth century before converging following the First World War.

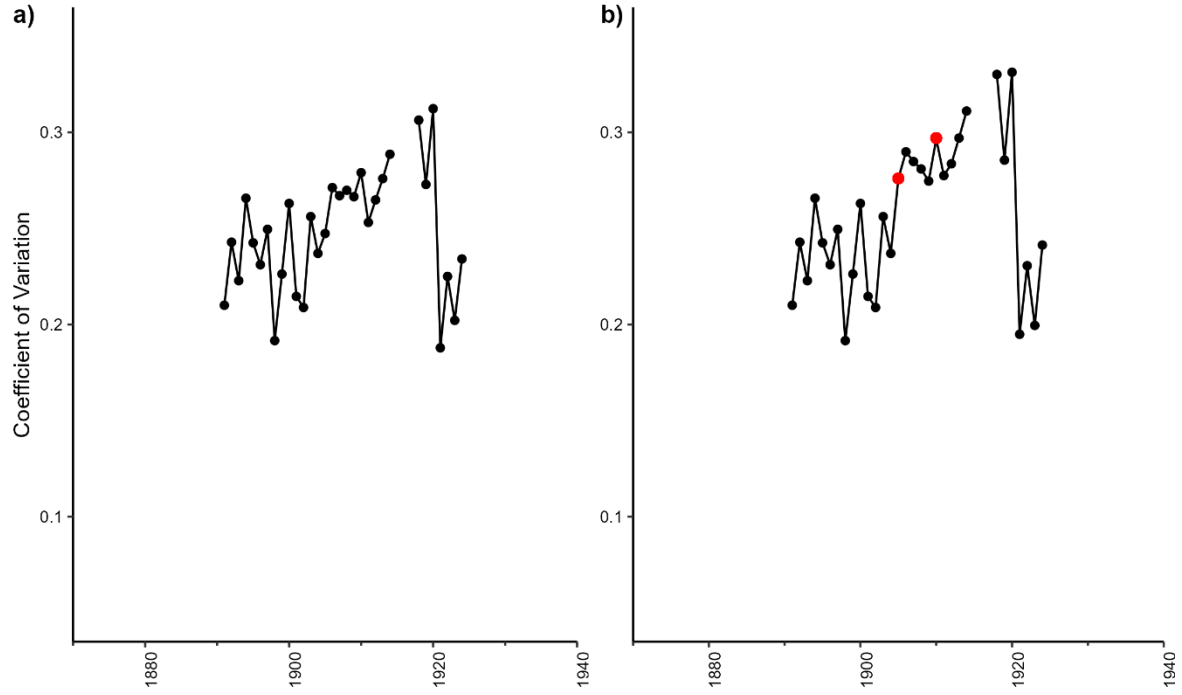


Figure 3-12. Coefficient of variation of crude death rates in Manchester
Black dots show individual years, 1891-1924 excluding 1915-17: a) for 18 statistical divisions and b) including new statistical divisions that joined the city in 1905 (Moss Side and Withington) and in 1910 (Gorton and Levenshulme), with these dates indicated by red dots.

Concern is expressed in the 1921 Medical Officer of Health report for Manchester that the population figures for 1920 were too high and that those for 1921 may also be inaccurate (Niven, 1922, p3), which could impact on the apparent death rates for these years. For reasons that are discussed in more detail in Appendix 8.2.3, it is likely that in both plots in Figure 3-12 the coefficient of variation is overstated in 1920 and understated in 1921. However, even ignoring the data points for these two years, we see a fall in the variation between statistical divisions in the 1920s as compared with the position prior to the First World War.

The available data for Manchester show a divergence in mortality rates between the high mortality and low mortality areas in the early part of the period studied. We know from results in Chapter 2 that the mortality of the Manchester divisions over the decades to 1924 was closely associated with socioeconomic circumstances in 1891, with lower socioeconomic conditions being linked to higher mortality rates. Figure 3-12 again shows that not only did these high socioeconomic/low mortality areas start from a better position, but that their mortality position improved vis-à-vis the high mortality divisions for almost 20 years, until after the First World War. Despite the difference in the length of the time series for Manchester and Glasgow, the First World War seems to have been the point at which both cities began to see a convergence in their small area mortality rates. We know from other studies that income inequality is likely to have started declining after 1911 (Lindert, 2000), and this does appear to be a lower bound for the reduction in mortality inequalities in my datasets. It has also been suggested that the First World War had an equalising effect on many of the countries involved (e.g. Mann, 2012, Schneider, 2023) and it may be that this influence played out in Glasgow and Manchester, although the extent to which we see this varies. Although the coefficient of variation eventually falls in both cities, it is higher for Manchester than for Glasgow in this post-war period (noting that we are only able to view a small number of years in Manchester). It is not possible to state why the two cities should differ, although one can speculate that there may have been differences in the municipal interventions in the two cities. Convergence in Manchester may continue after the end of the time series, but it is clear that by 1924 full convergence in mortality was far from being achieved.

Despite the falling death rate from around 1870, there was initially a significant divergence in death rates within both Glasgow and Manchester between the higher and lower mortality areas. This divergence was followed by convergence, although the pattern played out slightly differently in the two cities. The dispersion between wards was higher in Glasgow in the early part of the period being studied, but, following First World War, fell to a lower rate (under 0.2) than was achieved by Manchester.

The mortality transition brought with it other changes such as reductions in fertility, increases in education and higher income levels (e.g. Dyson, 2010, Galor, 2011). My results suggests that the gap between those who had access to these benefits and those who did not would have increased for lower socioeconomic areas of Glasgow and Manchester as compared with higher socioeconomic areas, at least until around the First World War. Although we then see convergence, this convergence is never complete, meaning the impact of socioeconomic conditions in the late 1800s is still having a significant effect on the life chances of people decades later.

3.6 Timing differentials in the mortality transition

3.6.1 Creation of the years ahead or behind measure

To assess the importance of the differences in the mortality transition discussed in previous sections, I have created a new measure, which I have termed ‘years ahead or behind the city’. This is a useful interpretive tool which compares the mortality rate of smaller administrative areas to the city average trend mortality rate. In particular, this variable measures, in years, how far in advance or behind small area mortality is as compared with city average mortality in each year. If the number of years is positive, then the area is in advance of trend mortality at the city level. If the number is negative, it shows how far the small area is behind the city trend. This number of years can be converted to generations, which may aid interpretation.

The years ahead or behind measure is calculated by matching the observed mortality rate for the focal small area in the focal year to the closest value on the logistic trend death rate for the city, obtaining the year in which this value

occurred, and then calculating the number of years between this and the focal year. The calculation takes place in two steps. First, I compute the difference between the observed mortality rate for the focal area and the trend mortality rate of the city and compute the minimum value amongst these differences. This can be written

$$\frac{min}{\tau\ \varepsilon\ T}\ = \{D_\tau - \ d_{it}\}$$

Where d_{it} is the observed mortality rate in focal area *i* in focal year t (in the small area range), D_τ is the city average trend mortality rate for year τ, and T is the set of all years for which the trend mortality rate is available at the city level (the city range). I then obtain the year τ where this value was minimised, which I call t_f, which gives me the year for which the city trend most closely matched the observed value in the focal area in the focal year. Finally, I calculate the difference between the focal year and the closest city trend year to give me years ahead or behind

$$years\ ahead\ behind = \ t_f - t$$

The range of years for the two cities and the small areas within them differ due to differences in data availability. For Glasgow, the city trend death rate range is 1855-1955. The first year is chosen as it is the start of the annual data series; prior to 1855 there are gaps between years. For Manchester, I have city annual death rates for 1837 to 1955, so the range here is 1837-1955. The year 1955 has been selected as the final year in both datasets because after this time the crude death rate rises due to changes in the age structure of the population[14]. For Glasgow, the small area range is 1891-1937 and for Manchester it is 1891-1924. In the figures below, when the closest year to the ward death rate is at either of the end-or-series points, this is indicated by colouring the plotted line red. This change of colouring indicates that this calculation of years ahead or behind is a lower bound because, in some cases, there is no value in the city

[14] As the proportion of the elderly in a population increases following the mortality transition, the crude death rate rises (e.g. Gendell, 1984).

trend that is sufficiently low (or high) to match the observed death rate in the small area in that year.

3.6.2 Years ahead or behind: Glasgow

The years ahead or behind values have been plotted for a selection of Glasgow wards: Figure 3-13a) shows three wards which were generally ahead of the city average death rate and Figure 3-13b) three wards which were generally behind.

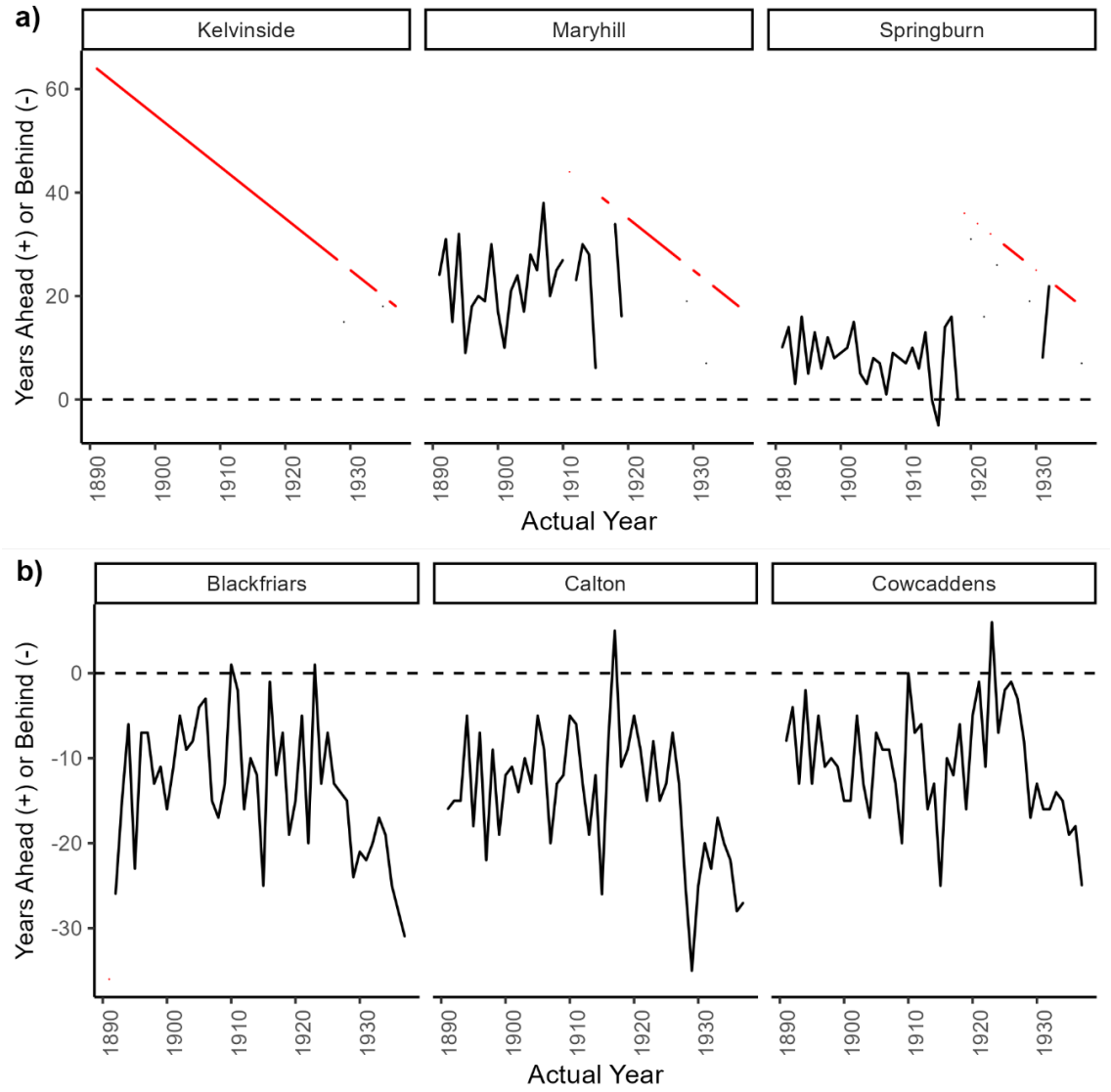


Figure 3-13. Plot of years ahead or behind, Glasgow 1891-1937
Calculated using the city average death rate 1855-1955 for selected wards, 1891-1937. Black indicates a true years ahead or behind position and red indicates estimated years ahead or behind compared to the start or end of the city data series (i.e. a minimum number). Zero is marked by a dashed line. Values above zero show the ward was ahead of the city average and values below show it was behind. a) Three wards mostly ahead of the city; b) three wards mostly behind the city.

Figure 3-13 shows us that in 1891, when Kelvinside became part of Glasgow, it was a minimum of 64 years ahead of the city; that is, it had a crude death rate that was closer to the city average death rate at the end of the data series than to any other year. In fact, the city average crude death rate never fell to such a low level as Kelvinside was experiencing as far back as 1891. Blackfriars, on the other hand, was at least 36 years behind the city average, as the closest city year was the very start of the series in 1855. Blackfriars' death rate became closer to the city average for a time, but by 1937 it had again fallen back to be 31 years behind, or equivalent to the city death rate in 1906. For completeness, years ahead or behind plots have been created for all 25 Glasgow wards from 1891 and are shown in Appendix 8.2.4, Figure 8-7.

If I compare the Glasgow wards which had the highest number of years ahead and the highest number of years behind at the start of the time series in 1891, there was a gap of at least 100 years. The death rate in the highest mortality ward in 1891 was closest to the city death rate in 1855, so this ward effectively had the mortality experience of the city around 1855. The lowest mortality ward was closest to the city death rate in 1955, meaning that in 1891 this ward was experiencing a mortality rate that the city would not get close to for decades. If I take a generation to be around 27 years[15] this would correspond to a gap of between three and four generations. This differential in years between the highest and lowest mortality wards appears to have narrowed by 1937, but was at least 55 years, or about two generations, underlining that, although mortality inequalities may have reduced, they did not disappear.

3.6.1 Years ahead or behind: Manchester

In late nineteenth century Manchester, as with Glasgow, there was a large gap between those areas which were ahead of the city trend death rate and those which were behind. Figure 3-14 shows a selection of wards that were ahead of the city in terms of their death rate (top row) and those that were behind (bottom row). In the 1890s Crumpsall and Moston had relatively small populations of under 10,000 which may account for some of the wide

[15] This calculation was taken from the 1911 census data, which showed that the average age at marriage was around 25 for women and over 60% of marriages had produced children within two years (Dunlop, 1914).

fluctuations in their years ahead or behind measure. In their best year, 1894, both divisions' death rate was 60 years ahead of the city average, meaning that it would be 60 years before the city average mortality reached the level that Moston and Crumpsall saw in 1894. The worst performing division in 1894 was Ancoats, which was 16 years behind the city average. These two gaps combined add up to a total of 76 years: in 1894 the residents of Ancoats experienced mortality levels that residents of Moston had last seen almost three generations previously. In 1899, when the gap was at its largest, it was 88 years or over three generations; this gap was between Crumpsall, 43 years ahead and Ancoats, 45 years behind.

Years ahead or behind plots for all 18 Manchester statistical divisions, 1891-1924, are shown in Appendix 8.2.5, Figure 8-8. In 1924, the last year for which data are available for statistical divisions, the gap between the highest and lowest mortality wards was 64 years, but it had been as low as 50 years in 1921. Although the gap had narrowed since 1899, its worst year, it still equated to around two generations. This is very similar to the situation in Glasgow in 1937, confirming that, although the disparity between small area mortality rates did narrow after the First World War, the two cities continued to see mortality differentials of multiple decades well into the twentieth century.

The years ahead or behind measure is a visible illustration of the different experiences of the mortality transition within the same city. In Chapter 2 we saw that mortality rates were closely associated with socioeconomic conditions, and we see that this disparity in socioeconomic conditions also plays out when we look at the years ahead or behind position of the individual areas. The wards which are far ahead of their respective cities, such as Kelvinside and Cheetham, are indeed those who had among the best socioeconomic conditions at the start of the period, whereas Blackfriars and Ancoats were among those with the worst socioeconomic conditions.

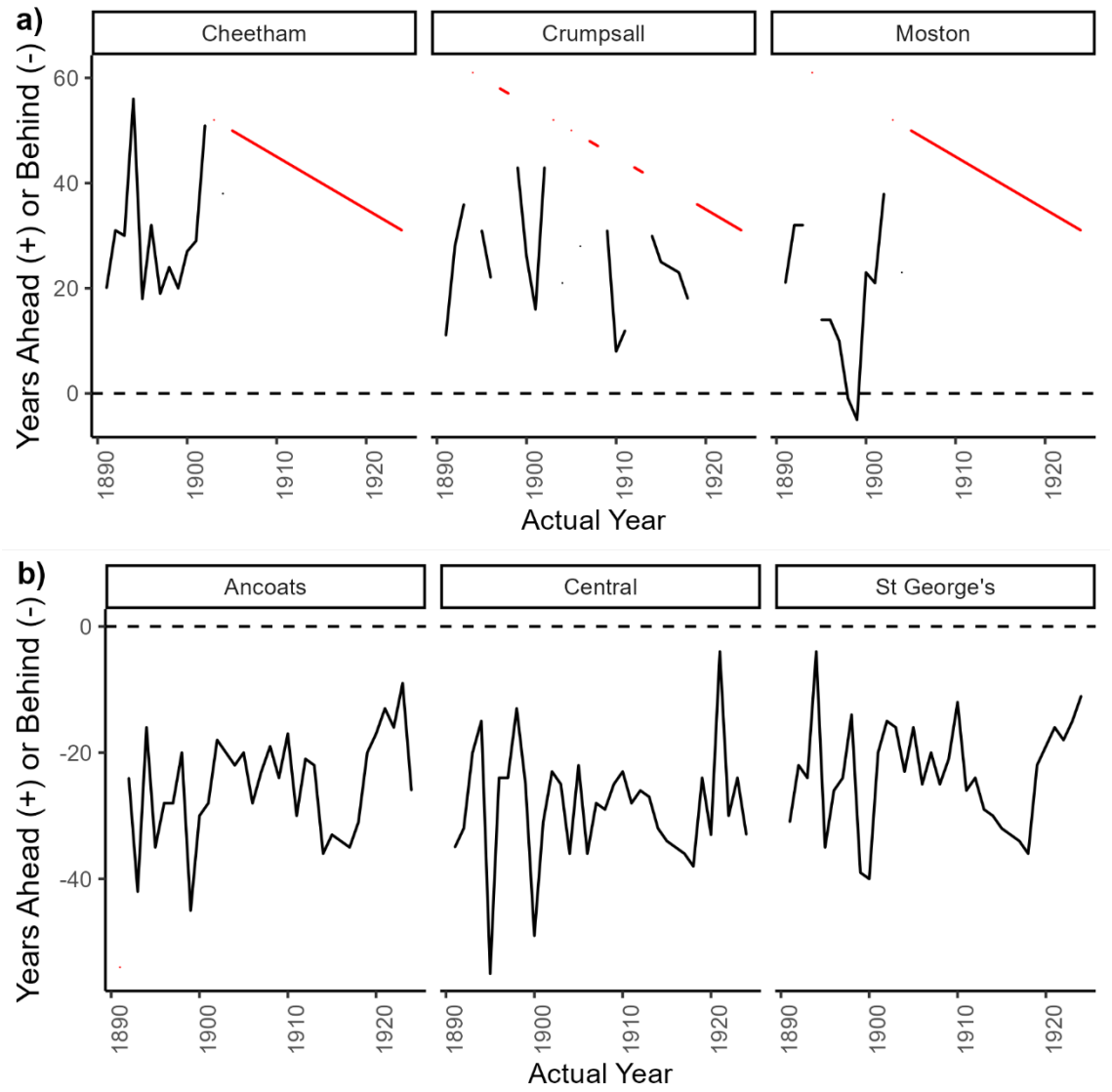


Figure 3-14. Plot of years ahead or behind, Manchester 1891-1924
Calculated using the city average death rate 1837-1955 and for selected statistical divisions, 1891-1924. Black indicates a true years ahead or behind position compared to the start or end of the city data series and red indicates estimated years ahead or behind (i.e. a minimum number). Zero is marked by a dashed line. Values above zero show the division was ahead of the city average and values below show it was behind. a) Three divisions which were generally ahead of the city average ; b) three divisions which were generally behind the city average.

3.7 Discussion: Dynamics of the mortality transition in Glasgow and Manchester

The mortality transition is a term used to describe the change from sustained high mortality rates to sustained low rates, a process that was experienced in the United Kingdom between 1850 and 1950. The cities of Glasgow and Manchester showed a remarkable similarity in the timing of this transition, despite being located 220 miles apart and subject to separate legal jurisdictions. Public health interventions at the municipal level underpinned the declines in

mortality, but access to these benefits varied within the two cities and was linked to small area differentials in socioeconomic conditions.

The sigmoid shape of a logistic function fits the pattern of mortality declines at the country and city level. It shows initial high death rates followed by a decline, first at an increasing rate (concave curve) then, after the inflection year, at a decreasing rate (convex curve), before finally settling at a new low level. The inflection year marks the point of the maximum fall in the death rate. The timing of the inflection year was around 1900 for the countries of Scotland and England and Wales, and around 1890 for the two cities.

The sigmoid shape of the fall in the trend mortality rate fits with the theory of the diffusion of technology, where new technologies are initially adopted by a small number of wealthier individuals. Health technologies in the nineteenth century included access to plentiful clean water and water closets, which allowed improved levels of hygiene, and more plentiful and safer food. Early access to these benefits required resources which were only available to a small proportion of the population, meaning there was initially only a small fall in overall mortality. As the technologies became cheaper, and/or income levels rose, more people could access the new technologies leading to a rapid fall in mortality. Once most people had gained access to the benefits of these technologies, the rate of fall of the death rate slowed and eventually the trend line became flat.

The mortality transition in many of the Glasgow wards can be shown by fitting a logistic function to the observed mortality data. In Chapter 2, I showed that wards with higher socioeconomic conditions experienced lower mortality levels in the late nineteenth and early twentieth centuries. I now show that these wards also underwent the transition earlier than low socioeconomic wards, as indicated by an earlier inflection year. Experiencing an earlier transition means that these higher socioeconomic wards pulled away from the lower socioeconomic wards in terms of their mortality rates, meaning that there was, initially, divergence between areas of higher and lower mortality. Once the lower socioeconomic wards entered the mortality transition themselves, the gap in mortality rates narrowed, and there was convergence between wards. This

pattern of divergence followed by convergence can be seen in both Glasgow and Manchester when we examine the coefficient of variation between the mortality in small areas, with convergence being seen from around the time of the First World War. Even by the end of the period, however, there is still a clear difference between death rates in the high mortality and low mortality areas, meaning we do not see complete convergence. Areas with lower socioeconomic conditions did eventually benefit from the mortality transition, although not all can be said to have completed the transition by the end of the time period studied: the Glasgow wards dataset ends 1937 and the Manchester statistical division dataset in 1924.

A new measure, years ahead or behind the city average mortality rate, is used to identify the marked mortality differentials between small areas of the cities. This measure shows how far ahead or behind the mortality in a ward or division was compared with the average city mortality. At the beginning of the period, the gap between the small areas that were furthest ahead and those that were furthest behind was at least three generations in both Glasgow and Manchester. By the end of the period, the gap had fallen to around 50 years or about two generations. Although overall mortality rates had improved, both cities still experienced considerable inequality in terms of mortality at the end of the period studied.

The dynamics of the mortality transition were experienced differently in different small areas of Glasgow and Manchester. Better initial socioeconomic conditions were associated with undergoing the transition sooner and led to a divergence in mortality rates between areas of higher and lower socioeconomic circumstances. Although mortality rates later began to converge, significant inequalities remained, suggesting that socioeconomic conditions in the 1890s had implications for mortality levels thirty or forty years later. Lower mortality rates are associated with other benefits such as better education leading to greater accumulation of human capital and higher incomes. These implications of socioeconomic conditions for mortality therefore have ramification far beyond health. The relationship between initial socioeconomic conditions and the dynamics of the mortality transition emphasises the long-lasting impact of socioeconomic inequalities.

Chapter 4 Socioeconomic influences on vaccine refusal: objection to vaccination in early twentieth century Glasgow

4.1 Introduction

In the early twentieth century, parents in Scotland were able to make far fewer choices regarding the health of their children than became available to them subsequently. The serious diseases of childhood were largely infectious, and how much a family suffered was closely related to income, with childhood mortality far higher among the poor (e.g. Cage and Foster, 2002, Jaadla et al., 2020, Preston and Haines, 1991). One of the few decisions over which parents did have agency was regarding the vaccination of their children against smallpox, once vaccine refusal became legal in Scotland in 1907. My analysis uses Glasgow administrative records of parental refusal to vaccinate their infants, after 1907, to determine whether there is any association between socioeconomic conditions and the choices made. This analysis builds on our earlier work which showed that prior experience of smallpox impacted on parental vaccination choices, with socioeconomic conditions being included merely as control variables (Angelopoulos et al., 2023, Mancy et al., 2024).

Despite the importance of vaccination to improvements in public health (e.g. Piot et al., 2019) and the good safety record of vaccines (Dudley et al., 2020), the late twentieth century saw an epidemiologically significant increase in vaccine refusal. Vaccine refusal is likely to be the outcome of multiple contributing factors (e.g. Larson et al., 2014), with the importance of socioeconomic conditions having been highlighted in work on recent vaccine refusal (e.g. Kohlhammer et al., 2007, Larson et al., 2016, Peretti-Watel et al., 2014). The link between vaccine refusal and social class had been discussed in the more limited number of works on historical vaccine refusal (e.g. Porter and Porter, 1988, Durbach, 2002). By using quantitative analysis, I am able to identify to what extent the relationship between socioeconomic status and vaccination refusal existed closer to the time that vaccine refusal emerged, and how it changed over time. If this relationship is long-lasting, it suggests a long-term societal structure that is unlikely to change rapidly.

The analysis in this chapter is an extension of a paper and a book chapter I wrote with colleagues which examined the influence of prior disease experience on smallpox vaccine refusal, using data on variation in vaccine refusal and its potential determinants from small areas within Glasgow at the beginning of the 20th century (Angelopoulos et al., 2023, Mancy et al., 2024). In that work, prior experience of smallpox was found to have a significant, sizeable and negative impact on vaccination refusal rates, with that impact declining over time, while socioeconomic conditions were only included to provide context for the effect. Here, instead, I examine the dynamic impact of socioeconomic conditions, distinguishing between aspects of these conditions, to understand their persistence over time. My study differs from recent studies of the importance of socioeconomic conditions for vaccine refusal because it analyses vaccine refusal during a period which saw rapid falls in infectious disease incidence compared to previous centuries, but which nevertheless saw much higher mortality than in recent decades, so awareness of the dangers of infectious disease should have been high.

I undertake a regression analysis of the relationship between socioeconomic conditions and vaccination refusal rates in Glasgow from 1907-13. I conduct this analysis for three socioeconomic measures: population density, persons per room and percent Irish born. These three measures were all taken from 1901, the closest value available prior to 1907, and the impact was allowed to vary over time by introducing a time trend. I repeat the analysis for a longer period following the First World War, 1921-31, using values for population density and persons per room from 1921 and again introducing a time trend.

My research suggests that socioeconomic conditions were an important influence on vaccine refusal in early twentieth century Glasgow, with higher socioeconomic conditions generally associated with lower rates of vaccine refusal. The dynamic impact of persons per room, a marker of income, appears to have increased over the years, both before and after the First World War, suggesting that behaviour associated with this variable became more entrenched over time. On the other hand, the impact of persons per acre and percentage Irish born, although significant, did not appear to change. My research shows that the link between higher vaccine refusal and lower socioeconomic conditions

is not a recent phenomenon. Where parents could make choices relating to their children's health relatively unimpacted by cost considerations, as with vaccine refusal, there were marked differences in the choices made by higher and lower socioeconomic groups.

The remainder of this chapter is set out as follows. Section 4.2 is a review of literature on attitudes to vaccination and Section 4.3 briefly considers the situation of Glasgow with regard to smallpox and vaccination in the early twentieth century. Section 4.4 summarises an earlier paper on this topic which focusses on the dynamic impact of prior disease experience on vaccination refusal. Section 4.5 discusses the statistical models used in this chapter and Section 4.6 presents the results. Section 4.7 discusses my findings.

4.2 Literature review

4.2.1 Vaccine hesitancy

Prior to 1907, the vaccination of infants against smallpox was mandatory in Scotland, but the Vaccination (Scotland) Act 1907 (1907) made refusal legal for the first time. Refusing or consenting to receiving vaccination, either for yourself or your children, therefore became an area of health where choices could be made. Vaccine refusal, more recently termed vaccine hesitancy, is the outcome of a variety of contributing factors (e.g. Larson et al., 2014). In the '3 Cs' model of vaccine hesitancy, possible determinants are organised into three types: convenience, confidence and complacency (MacDonald, 2015). Convenience focuses on issues such as availability, accessibility and affordability. Confidence relates to faith in the efficacy and safety of vaccines and how and why they are delivered and who they are delivered by. Complacency captures the idea that the risk of diseases that can be prevented by vaccine is low, so vaccination is not worthwhile. The uptake or refusal of vaccination depends on the balance of perceived risks associated with the vaccine and the disease it targets.

Prior to the latter part of the nineteenth century, there were relatively few health risks over which parents in the United Kingdom could exercise agency. From around the 1890s, parents with higher socioeconomic status began to be

able to make health-related choices, but due to a lack of resources the absence of agency remained true for poorer parents (Pooley, 2010). Prior to the mortality transition, which started around 1870 (see Chapter 2), the majority of deaths of children were from infectious diseases (e.g. Flinn, 1977) for which little or no medical treatment was available and over which parents had little control. It was only after the acceptance of the germ theory of disease, which showed how diseases spread and therefore what actions could be taken to combat this spread that parents with adequate resources could make choices relating to, for example, hygiene (e.g. Preston and Haines, 1991). Given the constraints on poor households in Glasgow, the majority of whom lived in houses of less than two rooms in the late nineteenth and early twentieth centuries (Cage and Foster, 2002, Chalmers, 1902a), the ability to provide a spacious, clean, ventilated environment and sufficient nutrition was extremely limited. These things were not a matter of choice: they were predetermined by the family's income. As there was no welfare state, if a family could not afford these, they could not have them.

The vaccination of infants against smallpox had been compulsory in Scotland since 1863 (1863). Following the passing of the Vaccination (Scotland) Act 1907, conscientious objection to vaccination became legal[16]. From 1907 onwards, therefore, vaccination became an area where Scottish parents could make a choice regarding their child's health that was not, as far as can be judged, directly dependent on resources. Both vaccination or the refusal to vaccinate were legal processes that involved some effort and cost (Angelopoulos et al., 2023). Parents were able to undertake their own evaluation of the relative risks and act on the conclusions they reached. Analysis from earlier periods suggests that parents' behaviour was fashioned by choices made subject to constraints, with parents who avoided the inoculation of their children against smallpox in the 18th century doing so dependent on the competing risks (Davenport, 2020). A study considering three areas of England in the nineteenth century highlights conflicts between poor parents and authorities, who took different considerations into account when balancing risk, with attendance at school and vaccination both being mentioned as areas of conflict (Pooley, 2010). I have not

[16] At this time, smallpox was the only disease against which vaccination was available, so any discussion of vaccination refusal in the historical context concerns smallpox vaccination.

come across any studies which specifically link socioeconomic conditions with parental choice over matters related to health, which I am able to do here with regard to conscientious objection to vaccination in Glasgow in the early part of the twentieth century.

4.2.2 Vaccination and socioeconomic status

Decisions leading to accepting or refusing vaccines are influenced by many factors including beliefs, attitudes and social effects related to social class and other socioeconomic characteristics, which influence an individual's calculation of risks (Durbach, 2002, Oraby et al., 2014, Peretti-Watel et al., 2014). Research using data from recent decades has shown that rates of vaccine refusal vary at different scales – between countries (Larson et al., 2016), within the same country (Piot et al., 2019), and even within smaller geographic areas such as states (Ernst and Jacobs, 2012, Lieu et al., 2015, Omer et al., 2008, Reich, 2020) – suggesting that the relative strength of different determinants, which include socioeconomic characteristics, varies by geographic area.

Historical studies document that the antivaccination movement in England in the 19th century varied by social class. It was stronger among lower social classes and often had links with campaigns for the right (of men) to vote (Durbach, 2002, Durbach, 2005). The ability to make decisions over the health of one's body and one's children's bodies was held to be just as much a basic right as the right to vote, and many of the early opponents of vaccination claimed they were rightly exercising their rights of citizenship in doing so (Durbach, 2002). In the wake of the 1867 Vaccination Act in England, the National Anti-Vaccination League was founded in 1874 (Durbach, 2005, p39). Many working-class districts had particularly high levels of anti-vaccination sentiment, for example Mile End in London had only a 43% vaccination rate among newborns in 1896 (Durbach, 2002, p68). Even when conscientious object to vaccination became legal in England in 1898 (1898), many working-class anti-vaccinationists refused to accept that they needed to go through the initially arduous process of claiming conscientious objection (Durbach, 2002, p70), while on other occasions the middle-class magistrates refused to grant certificates to working men who they 'held up for ridicule' (Durbach, 2002, p73).

More recently, vaccine hesitancy around childhood vaccinations has been linked to socioeconomic conditions in two contrasting ways: children from lower socioeconomic families were generally less likely to receive the full programme of childhood vaccines, especially where vaccination incurred a financial or administrative cost; however, objection specifically to the MMR (measles, mumps and rubella) childhood vaccine was more common among middle class parents (Bocquier et al., 2017). Poor uptake of the influenza vaccine in adults has also been linked to low socioeconomic conditions, as measured by income and education, with the main driver of a low uptake being a lack of information (Kohlhammer et al., 2007). The personal influence of doctors and other health professionals has been found to have a key bearing on an increased uptake of vaccination (e.g. Endrich et al., 2009, Holmberg et al., 2017). The recent Covid-19 pandemic brought vaccine hesitancy to the fore in both political and medical debates, with lower socioeconomic households demonstrating higher levels of vaccine hesitancy, which has been associated with lower education levels (Robertson et al., 2021) and low levels of trust in public sector officials (Chaudhuri et al., 2022, Perry et al., 2021).

In the context of early twentieth century Glasgow, individuals from lower socioeconomic households were known to have lower levels of education, as continuing schooling after the age of thirteen incurred actual and opportunity costs (Fraser and Maver, 1996). In addition, because most healthcare had to be paid for, either privately or via charitable donations, it is likely that better-off families had more contact with medical professionals than poorer families, and therefore more opportunity to be influenced by them in favour of vaccination. It is unclear what the levels of public trust were in the authorities such as those administering vaccination in Glasgow at this time, although, compared with the situation in England, organised objection to vaccination was not particularly strong in Scotland (Brunton, 2008).

4.3 Glasgow in the early twentieth century

4.3.1 Recording of administrative statistics

As discussed in Chapter 2, Glasgow had a good system of collecting administrative statistics in the late nineteenth and early twentieth centuries,

with the reports of the Medical Officer of Health being particularly detailed. Most of the data used in this chapter are sourced from these reports. Prior to 1903, data were recorded by sanitary districts, from 1903 to 1920 by original municipal wards and from 1921 onwards by realigned municipal wards. The method I have used to translate data between geographic areas is discussed in Section 2.4.1 and in detail in our paper on the influence of prior smallpox experience on vaccination (Angelopoulos et al., 2023). Census data are available for years 1901, 1911 and 1921, and provided measures indicating socioeconomic conditions which were not always included in the Medical Officer of Health reports. The variable for conscientious objection to vaccination 1907-13 is taken from the earlier paper on the impact of smallpox experience on vaccination refusal (Angelopoulos et al., 2023) and for 1921-31 comes directly from the Medical Officer of Health reports.

4.3.2 Smallpox

Smallpox vaccination of infants was made mandatory in Scotland in 1863 and remained compulsory until 1907. According to the Vaccination Act of 1863, children should be vaccinated by the age of six months (1863, p63). Births were registered in the registration district where the birth took place, which was usually at the home address. When a birth was registered, the parents were given a blank vaccination certificate which had to be completed and signed by a vaccinator, and then returned by the parents to the district registrar (1863, p3).

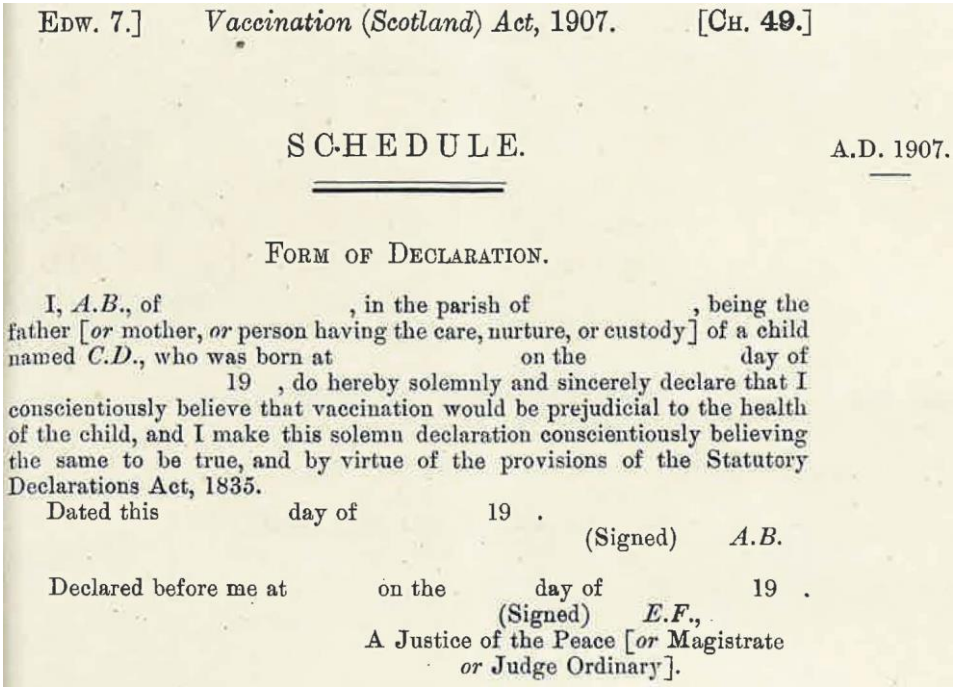
The data show that most parents took their child to a doctor for vaccination. They had to pay for the process to be undertaken, the cost of vaccination being *1s 6d – 2s 6d* (Brunton, 2008, p150-8). Average weekly wages in the UK were *£2 2s* in 1890 (Gazeley et al., 2023), so this would represent 3.5-6% of a weekly wage, a not inconsiderable amount. Many vaccinators ensured payment by refusing to complete the certificate until payment was made (Brunton, 2008, p153). Free vaccinations were available as part of the poor law provision but the proportion in receipt of this was very low, being less than 5% of total vaccinations in Scotland 1863-69 (Brunton, 2008, p155-6). In the early twentieth century in Glasgow, vaccinations could be provided free by officers of the

sanitary department, but the proportion receiving this service remained low at around 2-2.5% (e.g. Chalmers, 1901).

Smallpox mortality in the UK had fallen over the nineteenth century as voluntary vaccination increased and public health measures such as the isolation of patients and contacts came into force. Following the introduction of compulsory vaccination in Scotland in 1863, there was a further reduction in mortality (Brunton, 2008). In 1900-01 Glasgow experienced its first epidemic of smallpox since the 1870s, followed closely by a second one in 1903-04. During the first epidemic, there were 1759 cases and 234 deaths; the second epidemic was smaller, generating 1154 cases and causing 91 deaths (Chalmers, 1902c, Chalmers, 1904). These levels of infection and mortality were a great cause for concern, with the Medical Officer for Health, the press and the public all viewing them as alarming, and awareness the disease was widespread (Angelopoulos et al., 2023).

4.3.3 Vaccination refusal

The Vaccination (Scotland) Act 1907 (1907) allowed parents in Scotland to register ‘conscientious objection’ to the vaccination of their children against smallpox for the first time. A form, a facsimile of which is shown in Figure 4-1, was provided, with blanks for the names of the parent and child and spaces for signature by the parent and a magistrate or solicitor before whom the declaration was made. It should not have been difficult for most parents to complete this form, as literacy rates in Scotland were high following the Education (Scotland) Act of 1872 (1872) (Smout, 1986, p219). The act does not provide the cost of submitting the declaration, but it is likely that a solicitor’s fee would need to be paid, which was usually *1s 6d* (Lithiby, 1908, p118), similar to the cost of vaccination. The form then had to be posted or delivered to the registrar. Both the process of vaccination of children and that of submitting a conscientious objection to vaccination therefore implied some financial, time and/or other administrative costs; given additional costs such as travel to the medical or legal practitioner, it is not clear which choice would incur the highest time or financial cost.



EDW. 7.] *Vaccination (Scotland) Act*, 1907. [CH. 49.]

SCHEDULE. A.D. 1907.

FORM OF DECLARATION.

I, *A.B.*, of , in the parish of , being the father [*or* mother, *or* person having the care, nurture, or custody] of a child named *C.D.*, who was born at on the day of 19 , do hereby solemnly and sincerely declare that I conscientiously believe that vaccination would be prejudicial to the health of the child, and I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the Statutory Declarations Act, 1835.

Dated this day of 19 .

(Signed) *A.B.*

Declared before me at on the day of 19 .

(Signed) *E.F.*,
A Justice of the Peace [*or* Magistrate *or* Judge Ordinary].

Figure 4-1. Certificate for declaration of conscientious objection to vaccination
From Schedule I of Vaccination (Scotland) Act, 1907 (1907). Image courtesy of the University of Glasgow Library.

Vaccination refusal rates varied substantially between Glasgow wards after this process was made legal in 1907, ranging in that year from 0 to over 20% of the registered births (Table 4-1). Vaccine refusal rates subsequently increased, but there continued to be a between-ward variation. This issue was discussed in reports of the time (e.g. Chalmers, 1913) and is covered in detail in our 2023 paper (Angelopoulos et al., 2023).

Table 4-1. Descriptive statistics for conscientious objection to vaccination

Year	Minimum	Maximum	Mean	Standard deviation
1907	-	0.222	0.074	0.057
1908	-	0.176	0.084	0.041
1909	0.041	0.228	0.107	0.043
1910	0.064	0.241	0.135	0.044
1911	0.054	0.269	0.160	0.050
1912	0.082	0.333	0.190	0.066
1913	-	0.355	0.198	0.077

Notes: Figures are calculated as a proportion of all births, for 25 Glasgow wards 1907-1913 (adapted from Angelopoulos et al., 2023, Table S6).

4.4 The impact of prior smallpox experience on vaccine refusal

In our previous study, we showed that, in Glasgow, the experience of smallpox in the two epidemics between 1900 and 1904 was associated with subsequent rates of conscientious objection to vaccination (Angelopoulos et al., 2023). As my work in this chapter is an extension of that study, I briefly summarise it here. Our work focussed on both case rates and death rates from smallpox during the 1900-04 epidemics, and the conscientious objection to vaccination rates for 1907-1913. Smallpox experience varied markedly across geographical areas, as did rates of conscientious objection to vaccination. The aim of the paper was to examine if prior experience of smallpox impacted on subsequent vaccination decisions. If a lower case or death rate experience was associated with higher subsequent rates of conscientious objection, this would confirm the complacency hypothesis, that less personal experience of a disease leads to the perception of lower risk. The paper also included socioeconomic conditions as controls in the statistical model, as these might also impact on vaccination refusal. The socioeconomic variables used were population density 1911, rooms per dwelling 1911 and percent Irish born 1901. The impact of prior experience on subsequent vaccination refusal was analysed using linear and non-linear models.

The paper showed that conscientious objection to vaccination was strongly associated with prior smallpox experience, with higher levels of experience being linked with lower subsequent levels of vaccine refusal. Socioeconomic variables were also shown to be associated with vaccination refusal, but the model did not allow for this influence to vary over time. Figure 4-2, which is taken from the paper, shows the influence of the variables when looking at the 25 wards in Glasgow 1907-1913 and confirms that, broadly speaking, the impact of socioeconomic conditions and prior experience were comparable in magnitude. The association of the vaccine refusal rate with smallpox experience reduced over time (Figure 4-2A), whereas the association with socioeconomic conditions was static (Figure 4-2B).

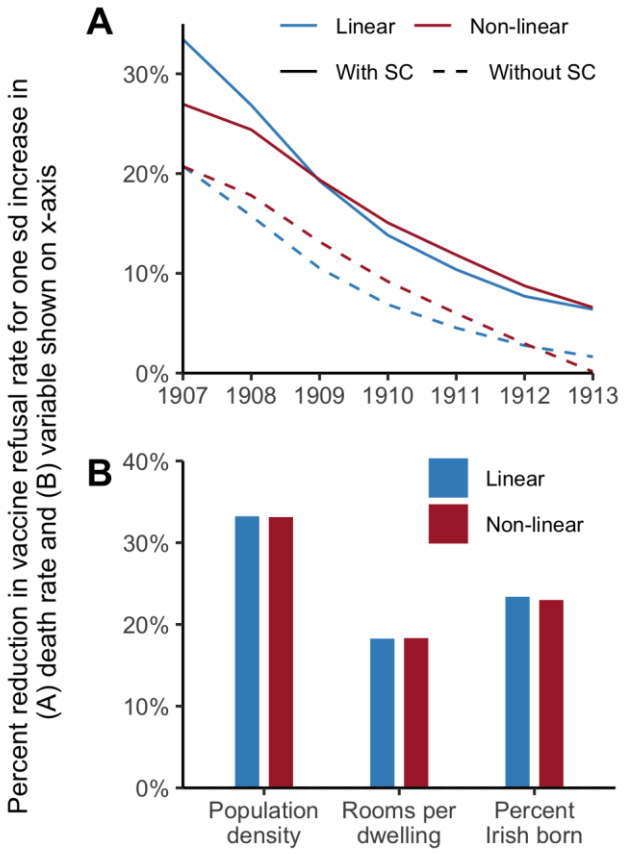


Figure 4-2. Percent reduction in vaccine refusal rate
Percentage reduction given a one standard deviation increase in the smallpox death rate during the 1900 and 1903 epidemics for the linear and non-linear models. The effects are expressed as the percent reduction in vaccine refusal relative to the average vaccine refusal rate in the corresponding year. The panel also includes results for a specification without variables relating to socioeconomic characteristics (SC); B. Percent reduction in vaccine refusal rate given a one standard deviation increase in the independent variable shown on the x-axis, for linear and non-linear models. The effects are expressed as percent reduction in vaccine refusal relative to the average vaccine refusal rate across all years (Angelopoulos et al., 2023, Figure 3).

4.5 Statistical models

Statistical models similar to that used in our earlier paper (Angelopoulos et al., 2023) were specified to test the association between socioeconomic variables that existed prior to the period being studied and the rates of vaccine refusal for two periods after 1907. I estimated a linear specification where y denotes the random variable that captures vaccine refusal rates after 1907 and the statistical models are given by:

$$y_{it} = \beta_1 + \beta_2 D + \beta_3 \mathrm{D} \times T_t + \beta_4 P + \beta_5 I + T_t + u_{it} \quad [3]$$

$$y_{it} = \beta_1 + \beta_2 D + \beta_3 P + \beta_4 \mathrm{P} \times T_t + \beta_5 I + T_t + u_{it} \quad [4]$$

$$y_{it} = \beta_1 + \beta_2 D + \beta_3 P + \beta_4 \mathrm{I} + \beta_5 \mathrm{I} \times T_t + T_t + u_{it} \quad [5]$$

for administrative units $i = 1, \ldots, N$ and years $t = 1, \ldots, \mathrm{N}$ (corresponding to 1907-13 or 1921-31). In these specifications, y_{it} is a measure of vaccine refusal in administrative unit i and year t; *D*is the measure of population density in 1901 or 1921; T_t is a time trend capturing changes over time that are common to all administrative units; P is the measure of persons per room 1901 or 1921; I is the measure of percent Irish born 1901; and the constant term β_1 captures common factors. Finally, u_{it} is an error term assumed to be independently distributed between administrative units; the error term is not assumed to be independently distributed within administrative units because of possible persistence of unobserved ward-level factors. For example, these may include random factors that differed between wards that may have affected people's beliefs, such as influential community leaders who were pro- or anti-vaccination.

The vaccine refusal rate y_{it} is defined as the number of children in ward i and year t (1907 onwards) whose parents registered conscientious objection to the vaccination of their child divided by the number of children born in that year in that ward. The socioeconomic conditions included in the specification were selected for the following reasons. Population density is measured by persons per acre, higher numbers of which might facilitate the spread of disease and thus suggest a higher risk of contracting smallpox. Higher population density should, other things equal, tend to reduce vaccine refusal. Persons per room is a measure of overcrowding within the home, which may act to increase the risk of disease, as with population density. It is also an indicator of income, as those with lower incomes were able to afford less space per person. It is possible that lower socioeconomic status influenced confidence in vaccine safety and effectiveness or expectations about future epidemics. Lower income groups have been shown in the literature to have higher levels of vaccine hesitancy (e.g. Durbach, 2002), and if this is the stronger influence, then we would expect higher levels of persons per room to be associated with higher levels of vaccination refusal. As we cannot be sure which choice, vaccination or vaccination refusal, incurred the lower cost, we cannot say how we would expect income effects to work with regard to those costs.

The variable percent Irish born is used as it may represent a difference in attitude or behaviour over and above the characteristics captured by the other

socioeconomic measures described above, such as cultural factors associated with being born in Ireland (see e.g. Devine, 2001). I include this measure to recognise the possibility of this difference, in particular because attitudes in Ireland were considered to be more positive to vaccination than elsewhere in the United Kingdom (Brunton, 2008). This indicator is not available for 1921 so [5] is not run for the 1921-31 period. An alternative indicator of income is rooms per dwelling, and this measure is used in the smallpox experience paper (Angelopoulos et al., 2023) with a higher number of rooms indicating a higher socioeconomic status. Rooms per dwelling and persons per room are closely negatively correlated so cannot be used together. To maintain consistency with the approach used in Chapter 2 and Chapter 3, the variable persons per room is used here as the socioeconomic indicator that represents income.

The interaction term $D \times T_t$ is included in [3] to allow the effect of persons per acre to change over time. The interaction term is similarly introduced into [4] and [5] to allow persons per room and percent Irish born also, independently, to vary over time. It is plausible that the effect of past socioeconomic conditions on decision making alters over time if the importance of the underlying socioeconomic factors captured by the variables become more (or less) closely associated with vaccine refusal as time progresses.

Descriptive statistics for the explanatory variables in 1901 and 1921 are given in Table 4-2, which includes rooms per dwelling for completeness, although this variable is not included in analysis in this thesis. All variables exhibited a large range between the wards which have the lowest and the highest values. I tested for correlations between the three explanatory variables used in the specifications and the levels were low (Appendix 8.3.1, Table 8-8). There were also no issues with collinearity, with all variance inflation factors being below two. I estimate the model parameters in [3]-[5] using least squares and computed clustered standard errors which allow the error term to be correlated over time for each administrative unit. In Appendix 8.3.2, I also present results from estimating the model parameters by a non-linear specification, for the 1907-13 period only.

Table 4-2. Descriptive statistics for socioeconomic conditions, Glasgow

	Minimum	Maximum	Mean	Standard deviation
Persons per room 1901	0.665	2.510	1.848	0.505
Persons per acre 1901	8.988	194.196	100.371	54.185
Rooms per dwelling 1901	1.799	8.356	3.124	1.701
Percent Irish Born 1901	2.320	16.250	8.358	3.747
Persons per room 1921	0.894	2.605	1.820	0.406
Persons per acre 1921	16.289	182.919	76.827	44.331
Rooms per dwelling 1921	1.726	4.882	2.612	0.718

Notes: Figures are for 25 Glasgow wards in 1901 and for 37 Glasgow wards in 1921.

4.6 Results

4.6.1 Socioeconomic influences on vaccine refusal 1907-13

I first consider the period immediately after the introduction of legislation allowing conscientious objection to smallpox vaccination in 1907. I include the seven years up to the First World War, to avoid any possible confounding factors of the war years. Coefficient estimates for the three equations specified above are shown in Table 4-3. The overall mean of the dependent variable, conscientious objection to vaccination, was 0.136 and the means of the explanatory variables are provided in Table 4-2. The marginal effects of socioeconomic conditions over time can be seen in Figure 4-3, with Figure 4-3a) showing that the association with persons per room is not only positive but increases over time. Figure 4-3b) suggests that the marginal effects of persons per acre and percent Irish born are much smaller and do not change much over time.

Population density (persons per acre) is negatively associated with conscientious objection to vaccination, meaning the more densely populated an area is the lower the rate of conscientious objection. The possible reason for this is high population density is likely to increase the risk of catching infectious diseases, so lowers the likelihood of objection to vaccination. The population density interaction term is not statistically significant. Percent Irish born is negatively associated with conscientious objection to vaccination, although the possible impact is small, with an increase of 1% in Irish born being associated with a fall in conscientious objection to vaccination of around 0.005. This association is in line with literature which suggests that there were lower levels of objection to

smallpox vaccination in Ireland. This cultural attitude appears to have persisted among the Irish born living in Scotland. The Irish born interaction term is also not statistically significant.

Persons per room represents overcrowding within the household, which is likely to impact on vaccination decisions by increasing vaccination rates to the extent that householders understand its contribution to the increased risk of disease in overcrowded accommodation. However, it is also a marker of income, with a higher number of persons per room suggesting less income is available to spend on rent. The association between persons per room and conscientious objection to vaccination is positive, suggesting that the perceived higher risk of disease is less important than other factors (note that, in this specification I have already controlled for possible effects of higher disease spread via persons per acre), leading to higher rates of vaccination refusal in areas with higher numbers of persons per room.

The model suggests that an increase of one person per room in 1901 is associated with an increase in the rate of conscientious objection to vaccination by 0.057 (model [3]). See Table 4-1 for descriptive statistics of the conscientious objection variable over the period. This finding is consistent with the explanation that, if cost is an issue, then objecting to vaccination incurred a lower cost than having the child vaccinated. As discussed above, it is not clear which financial cost was higher, so this cannot be excluded, but there is no evidence to further substantiate this argument. Another explanation is that higher income households are likely to be more educated, with more education leading to higher levels of confidence in vaccination. This may also indicate a generally higher level of confidence in medical and other authorities among the better off, or, conversely, a culture of distrust of authorities among the less well off. As discussed above, there is additional historical evidence that such class and education-related social factors were related to vaccine refusal in England (Brunton, 2008, Durbach, 2002). The influence of persons per room and the interaction term is also positive and highly statistically significant, so that in the results for equation [4] persons per room on its own has no statistical significance. This suggests that the factors this variable represents became stronger over time, with vaccination refusal becoming more widespread among

the lower classes. Overall, the results suggest that the impact of these socioeconomic factors make an important contribution to explaining the rise in vaccination refusal.

Given that there are only three explanatory variables plus the time trend in this specification, the R^2 values are relatively high, explaining almost 60% of the variation in rates of conscientious objection to vaccination. This suggests that socioeconomic conditions were a major influence on decisions around vaccination in 1907-13.

Table 4-3. Socioeconomic conditions and vaccine refusal rates, Glasgow, 1907-1913

	(3)	(4)	(5)
(Intercept)	0.041	0.111***	0.037+
	(0.025)	(0.026)	(0.021)
Population density 1901	-0.001***	-0.001**	-0.001**
	(0.000)	(0.000)	(0.000)
Year numeric	0.021***	0.004	0.022***
	(0.005)	(0.007)	(0.005)
Persons per room 1901	0.057***	0.016	0.057***
	(0.017)	(0.017)	(0.017)
Percent Irish born 1901	-0.005*	-0.005*	-0.006**
	(0.002)	(0.002)	(0.002)
Population density 1901 × Year numeric	0.000		
	(0.000)		
Persons per room 1901 × Year numeric		0.010***	
		(0.003)	
Percent Irish born 1901 × Year numeric			0.000
			(0.001)
R^2	0.574	0.594	0.573

Notes: Estimates shown for the specification in equations [3], [4] and [5]. Least squares estimation. Mean of the dependent variable (conscientious objection to vaccination) = 0.136. Robust standard errors clustered at the ward-level are shown in parentheses under the estimated coefficients. The dependent variable in all models is the vaccine refusal rate. Number of observations: 175 (25 wards); *** p < 0.001; ** p < 0.01; * p < 0.05; p-values are based on two-sided t-tests of statistical significance of the coefficient.

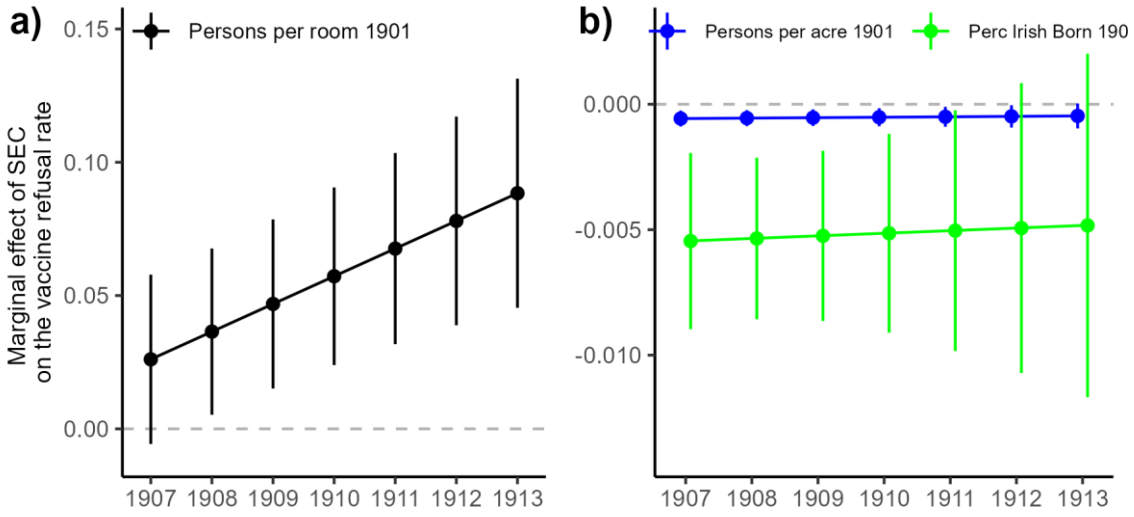


Figure 4-3. Estimated marginal effect of socioeconomic factors 1901 on the vaccine refusal rate in each year
Showing 95% confidence intervals for the linear model. The marginal effects are calculated as the effect of an increase of one unit in the socioeconomic variable on the vaccine refusal rate for the year shown on the x-axis. Note the y-axes differ: a) Marginal effects of persons per room 1901; b) Marginal effects of persons per acre and percent Irish born 1901.

Specifications [3]-[5] assume that the marginal effect of h on y is linear, although time dependent. However, as was noted in our earlier paper (Angelopoulos et al., 2023), the measures of vaccine refusal are in terms of proportions of infants and are thus bounded in the interval [0,1]. All measures are well below the upper bound but a few are at or near the lower bound. I therefore also present, in the appendices, results from a non-linear specification using fractional regression analysis (Appendix 8.3.2, Table 8-9). The association between socioeconomic conditions and vaccine refusal remains.

4.6.2 Persistence of link between socioeconomic conditions and vaccine refusal

Data on conscientious objection to vaccination were collected in Glasgow until 1931 and models [3] and [4] were also run for the last eleven years of the period. My aim was to test whether the association between socioeconomic conditions and vaccine refusal persisted at this later time. The years 1921-31 were selected to avoid any confounding factors due to possible behavioural change during the First World War or during a small outbreak of smallpox that occurred in Glasgow in 1920. It was not possible to run specification [5] as data

on percent Irish born were no longer collected. During the period 1921-1931 there were 37 wards in Glasgow.

The continued influence of socioeconomic conditions on vaccine refusal is confirmed by the coefficient estimates in Table 4-4. Population density continues to have a negative association with vaccine refusal, suggesting that areas of higher population density tended to have lower vaccine refusal rates. Persons per room again has a positive association with vaccine refusal. Both measures remain statistically significant when the interaction term is introduced. The logic of the association between the socioeconomic variables and vaccine refusal is as discussed above for the period 1907-13. The presence of the link between the variables in both time periods suggests that there is a persistent association between vaccine refusal and measures of socioeconomic conditions. As the specification in Table 4-4 includes fewer explanatory variables than

Table 4-3, it is not surprising that the R^2 values are lower. However, even without percent Irish born, the R^2 values for 1907-13 would be around 0.5. It appears, therefore, that although the influence of socioeconomic variables still existed in the later period, it was associated with less of the variation in vaccination refusal. It is not clear why this should be the case.

Table 4-4. Socioeconomic conditions and vaccine refusal rates Glasgow, 1921-1931.

	(3)	(4)
(Intercept)	0.082*	0.114**
	(0.037)	(0.038)
Population density 1921	-0.001***	-0.001**
	(0.000)	(0.000)
Persons per room 1921	0.078**	0.053*
	(0.026)	(0.025)
Year numeric	0.008***	0.003
	(0.001)	(0.002)
Population density 1921 x Year numeric	0.000**	
	(0.000)	
Persons per room 1921 x Year numeric		0.004***
		(0.001)
R^2	0.368	0.369

Notes: Estimates shown for the specification in equations [3] and [4]. Least squares estimation. Mean of the dependent variable (conscientious objection to vaccination) = 0.227. Robust standard errors clustered at the ward-level are shown in parentheses under the estimated coefficients. The dependent variable in all models is the vaccine refusal rate. Number of observations: 407 (37 wards); *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The marginal effects of socioeconomic conditions over the period 1921-1931 can be seen in Figure 4-4, with Figure 4-4a) showing that the association with persons per room is not only positive but increases over time. Figure 4-4b) suggests that the marginal effects of persons per acre are much smaller and do not change much over time. These findings confirm what was seen in the earlier period, that the impact of persons per acre is relatively static, but the impact of persons per room is dynamic and increasing.

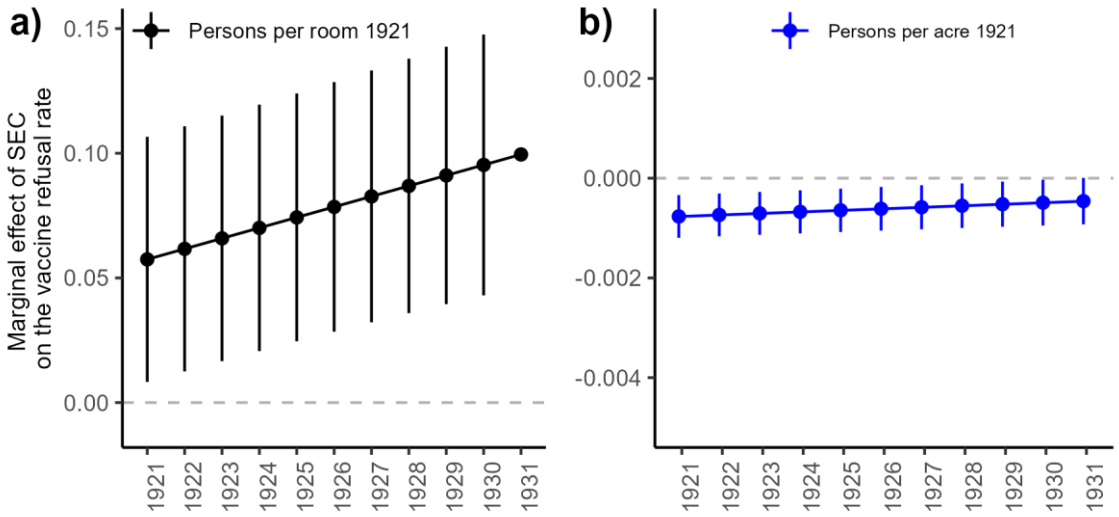


Figure 4-4. Estimated marginal effect of socioeconomic factors 1921 on the vaccine refusal rate in each year.
Showing 95% confidence intervals for the linear model. The marginal effects are calculated as the effect of an increase of one unit in the socioeconomic variable on the vaccine refusal rate for the year shown on the x-axis. Note the y-axes differ: a) Marginal effects of persons per room 1921; b) Marginal effects of persons per acre 1921.

4.7 Discussion: Vaccine refusal in early twentieth century Glasgow

This chapter shows that socioeconomic conditions can impact on health due to their influence on the choices that people make. In the example studied, the choice was whether or not to vaccinate children against smallpox. My findings contribute to the large literature on factors associated with vaccination decisions and show that socioeconomic characteristics influenced vaccine refusal over one hundred years ago. Considering data from Glasgow from 1907 onwards, higher population density and a higher proportion of the population born in Ireland were associated with lower rates of vaccine refusal. Higher persons per room, which would indicate lower income, was associated with higher rates of

vaccine refusal. The influence of the first two factors did not appear to increase over time, but there was a dynamic influence of persons per room which appears to have heightened over time. It is interesting to note that when examining the impact of socioeconomic conditions on mortality in Chapter 2, population density and persons per room were both positively associated with higher death rates; however, when considering decisions regarding vaccination, the influences of these two variables work in opposing directions. Higher population density is associated with lower rates of vaccine refusal, but higher persons per room is associated with higher vaccine refusal. This suggests that these two variables are representing different aspects of socioeconomic conditions.

It is hard to say exactly what it was about lower socioeconomic conditions as represented by higher persons per room that led to higher vaccination refusal, but mistrust of those in authority and lower confidence in the safety of the vaccine may have contributed, as it was thought to do at the time in England. If this was the case, the higher levels of confidence among the better off could be due to higher levels of education or to more trust in public officials. The long-term and increasing influence of this variable suggests that the behaviour associated with it became more entrenched over time.

This chapter extends the analysis of previous work on the impact of smallpox experience on vaccination decisions (Angelopoulos et al., 2023), indicating that socioeconomic facts should not merely be viewed as controls when examining other influences such as disease experience, but may be a significant influence in their own right. The dynamic influence of persons per room on vaccination refusal is particularly noteworthy.

In Glasgow, at the start of the twentieth century, my findings indicate that the association between socioeconomic characteristics and vaccination refusal was strong and statistically significant, and existed both prior to and following the First World War. Socioeconomic characteristics can be seen to have had an influence on vaccination decisions historically in ways similar to those seen in more recent times. This suggests the association between lower socioeconomic status and higher levels of vaccine refusal arises from long-term societal structures that are unlikely to change rapidly. The persistence of this association

implies the existence of embedded social attitudes, and suggests that any approach to influencing attitudes to vaccination will need to take this into account.

Chapter 5 Did rich breadwinners die older? Influence of occupational status on age at death in Nancy after 1895

5.1 Introduction

In this chapter I examine the influence of socioeconomic conditions on the age at death in a specific population: married men aged 26-49 years who died in Nancy, France, 1895-97. The deaths of this group were important, not only because they represent a key part of the working age population, but more particularly because their loss was likely to result in important consequences for the families left behind. I have constructed a unique panel dataset for households in Nancy, the focal event of which is the death of the male head of household, who I call the breadwinner. At this time in France, the husband was considered the head of the household and contributed the majority of the household's income. I also have a small control sample of households where the male head of household did not die. The dataset contains information on occupation, annual rent and house size, which can all be used as proxies of different aspects of socioeconomic conditions. In addition, the dataset includes various measures relating to household and family composition as well as the geographical location within Nancy. In the next chapter I will examine the impact of the death on the family left behind, a key motivating factor for the creation of the dataset, but I first consider whether socioeconomic conditions impacted on the death itself.

The importance of socioeconomic conditions for mortality has been studied in both current day and historical populations, with better socioeconomic conditions being associated with lower mortality (e.g. Bengtsson and Van Poppel, 2011, Di Girolamo et al., 2020). Socioeconomic conditions encompass a range of measures including social status, occupational status, education, income and wealth. Historical datasets often lack a number of these measures, in which case the measure may be dropped from the analysis, or other indicators may be used as a proxy (e.g. Jaadla et al., 2020, Woods, 2000). The occupational status of the male head of household is probably the most widely used marker of socioeconomic conditions in historical studies (e.g. Jaadla et al.,

2020, Preston and Haines, 1991, Woods, 2000, Wall, 2002). Some studies incorporate wealth (as measured by wealth left to heirs) (Jaadla et al., 2020) or home circumstances (proxied by infant mortality rates) (Woods, 2000). Other studies use rent as a proxy for income (Kesztenbaum and Rosenthal, 2016) but are not able to include data on occupation. To date, I have not found any studies which analyse the links between mortality and the breadwinner's occupation, income and other measures such as overcrowding and geographical location. The unique Nancy dataset enables me to undertake such an analysis.

In France, national censuses were generally undertaken every five years from 1801 until the Second World War, but the town of Nancy also undertook a detailed census (*recensement*) every year from 1795 to 1991. These very detailed censuses are a unique historical resource which forms the basis for my dataset. Because these censuses are annual, they provide much finer granularity than the more common quinquennial or decennial censuses. They permit me to trace individuals and families, showing details of changes in their circumstances at least annually and, due to constant revising, often more frequently. In addition, the Nancy censuses not only provide details on household members, occupations and dwelling size, but also include annual rent of the family dwelling, which is rarely found in other datasets.

The aim of my analysis was to quantify the association of a variety of measures with the age at death of the head of household. I constructed a dataset including measures of mortality and other variables sourced from the annual Nancy censuses. I used a least squares statistical model to examine the relationship between age at death and variables representing socioeconomic conditions and household characteristics. The use of more than one explanatory variable allowed the relative contribution of different aspects of socioeconomic and other characteristics to be examined.

The results of the statistical analysis show that breadwinners in my sample who had a higher occupational status tended to die at an older age than those with lower occupational status. This association with occupational status existed over and above effects of income, overcrowding or location within Nancy, suggesting that there is something about occupation itself that impacts on mortality. It was

not so much the rich who died older, but those who worked in higher status occupations. Nonetheless, the models used in my analysis only explain a small amount of the difference in the age at death of the breadwinners, indicating that for married men aged 26 to 49 years, most deaths were random with respect to socioeconomic conditions.

The remainder of this chapter is set out as follows. Section 5.2 reviews the existing literature on mortality by age and socioeconomic conditions in the late nineteenth century. Section 5.3 provides the historical and geographical context of Nancy. Section 5.4 describes how the unique dataset was created and 5.5 reviews the key characteristics of the data. Section 5.6 sets out the statistical models to be used and shows the results. Finally, Section 5.7 concludes the chapter, discussing the key points.

5.2 Literature review: mortality in nineteenth century Europe

5.2.1 Mortality and age

In late nineteenth century Europe, mortality rates varied widely by age, with the rates being highest in children up to the age of five years. This was highlighted by public health officials at the time and has been studied more recently by academic researchers. For example, English life tables show that the average infant mortality rate (deaths below the age of one) was 150 per thousand in the period 1838-54 and that for the period 1871-80 this had only fallen slightly to 144. In 1871-80, the annual mortality rate at ages one to four was lower, but still significant at 31.5 per thousand (Woods and Hinde, 1987). These high death rates in children were due to the infectious diseases of childhood, such as smallpox, measles and whooping cough, and the susceptibility of young children to diarrhoea. Overcrowded living conditions were strongly associated with a higher mortality rate, the main explanation usually being the higher transmissibility of diseases in these conditions, and the difficulty in maintaining standards of cleanliness (e.g. Cage and Foster, 2002). Infant mortality rates in nineteenth century France were similar, being around 145 per thousand 1835-45, rising to over 200 per thousand in the 1850s and 1860s then falling again to

around 150 per thousand births by the end of the century (Mesle and Vallin, 1991).

An alternative measure of mortality is life expectancy at birth. In England and Wales, this was around 41 years in the middle of the nineteenth century and had only increased to 43 by the 1870s (Szreter and Mooney, 1998). Life expectancy was higher for those who survived their early childhood; in 1867 life expectancy at birth was 41 years but life expectancy at age 5 was 55 years and at 10 was 57 years[17] (Registrar-General, 1867). Again the picture was similar for France, with life expectancy at birth in the low 40s for the period 1861-1885 (Felice et al., 2016, Mesle and Vallin, 1991, Preston and Van De Walle, 1978), but life expectancy at age five being 57 between 1881-1885 (Kesztenbaum and Rosenthal, 2016). Due to the large number of deaths in the under-fives, and the impact that improved mortality here could and did have on life expectancy, much academic work has focussed on mortality in these age groups, with far less examination of influences on the age at death in the adult population.

Death rates began a secular decline in Western Europe from around 1870 (e.g. Dyson, 2010, Sperber, 2009). The age groups which benefited first from these reductions in mortality were children and young adults (1861 onwards) followed by adults (1881 onwards), with infants and those over fifty only seeing improvements in their mortality at the end of the nineteenth century (Woods and Hinde, 1987). The potential for gains for adults aged 26 to 49 years was, however, relatively modest, as these age groups already had a low risk of mortality: in England and Wales the annual mortality rate was around 12 per thousand in 1838, falling to around 10 by 1900 (Woods and Hinde, 1987). France also saw relatively modest gains in the age range 26 to 49 years, with an annual death rate of around 11 per thousand in the 1850s, falling to around 9 in the 1890s (Mesle and Vallin, 1991)[18]. The risk of death for men of working age in late

[17] Life expectancy throughout this chapter refers to total life expectancy, not to additional years of life. The expected additional years of life at age five was, therefore, 50, and at age ten was 47.

[18] These figures might suggest that death rates in this age group in France were slightly lower than in England and Wales, but we cannot be sure the calculations are strictly comparable.

nineteenth century France, which are the subject of my study, was therefore relatively low compared to other age groups at that time.

5.2.2 Mortality and socioeconomic conditions

Mortality and other health outcomes are known to be closely associated with socioeconomic conditions (e.g. Pickett and Wilkinson, 2010, Rambotti, 2015), at least since the mid-eighteenth century (e.g. Antonovsky, 1967) and possibly earlier (e.g. Cummins et al., 2016). The links between income and mortality have been mapped to several intermediate steps such as access to better sanitation, nutrition and education, but it is also noted that high levels of income *inequality* also add to mortality inequalities (Marmot and Wilkinson, 2006, Matthew and Brodersen, 2018, McGrail et al., 2009, Wolfson et al., 1999). The fundamental cause theory of mortality inequalities (Phelan et al., 2004) states that those with access to more resources will always find ways to use these to improve their own health and mortality, so that higher income should automatically result in improved mortality. Although the fundamental cause theory has received numerous criticisms (e.g. in Bengtsson and Van Poppel, 2011), it is accepted that, certainly in Europe since the late eighteenth century, better socioeconomic conditions were generally associated with lower mortality.

Research focussing specifically on Western Europe in the nineteenth century shows that health varied by socioeconomic conditions, with mortality rates being far higher for the less well off (Antonovsky, 1967, Blum et al., 1990). The influence of socioeconomic conditions was particularly true for the young: Preston and Haines linked child mortality to the occupational classification of the husband of the family, and found that in England and Wales at the end of the century child mortality levels for unskilled manual workers were 23% higher than the overall average while the children of professional and higher-skilled white-collar workers had a mortality rate 13% lower than the average (Preston and Haines, 1991). Variations in infant mortality continued into the early twentieth century, with the children of unskilled workers in England and Wales in 1911 having a death rate 152.5 per 1000 births, but that of the highest social class being almost exactly half this, at 76.4 per 1000 births (Jaadla et al., 2020). Infant mortality was also found to be higher in urban than in rural settings and

higher in certain localities (Reid, 1997). In summary, paternal occupation, neighbourhood characteristics and, in some countries, religion, have all been shown to be related to variations in infant and child mortality (Connor, 2017, Jaadla et al., 2020). The impact of socioeconomic conditions on historical age at death of adults has been much less studied, although it has been suggested in work on Sweden that the relationship may be U-shaped, with higher mortality being seen both among the highest and the lowest social classes (Dribe and Erikson 2018, Bengtsson et al 2020). Adult mortality is also examined in work on life expectancy, see below.

As discussed in Chapter 3, many studies of nineteenth century mortality emphasise the importance of public health measures in improving health, such as the introduction of piped water and sewage treatment (the sanitation part of the intermediate steps mentioned above). These measures were usually introduced at the city level so in theory should have benefited all residents equally. In practice, access to the benefits brought by these public works also varied by social status, because certain parts of a city were connected first, or additional payment was required to bring services inside a house (see e.g. Kesztenbaum and Rosenthal, 2016). Therefore, even when it came to public health measures, socioeconomic conditions still played a role.

Researchers have found it difficult to partial out the influence of different aspects of socioeconomic conditions on historical mortality rates, for example studying the impact of income or wealth separate from occupational status, because of a paucity of reliable data. Jaadla et al analysed the impact of wealth in a sample of English parishes from 1813-37 using a measure based on whether a particular occupation was likely to leave a will and the median value of the assets that were left; they found that higher wealth was associated with lower early childhood mortality (ages one to four years) but not to lower infant mortality (under one year) (Jaadla et al., 2020).

Variations in life expectancy at age five by socioeconomic status provide some indication of adult mortality, as they remove consideration of the high-risk early years. In France, in 1881, life expectancy at age five showed a clear variation, being 51 years for the ‘worst’ ten percent of the population but 62 years for the

'best' ten percent[19] (Kesztenbaum and Rosenthal, 2016): the bottom and top decile here are merely defined by life expectancy and not linked to socioeconomic conditions. However, work on data for Paris in the period 1880-1913 found that the share of the rich (defined as paying at least 1000 francs in rent) in an *arrondissement* (district*)* added around four years to life expectancy for every standard deviation increase in this proportion (Kesztenbaum and Rosenthal, 2016).

Life expectancy at age 20, which by definition is not influenced at all by childhood mortality, has also been shown to vary by occupation in Victorian England and Wales. Professional men had a life expectancy of around 62 years, skilled manual workers 60 years and unskilled workers 55 years in 1860-71 (Woods, 2000). Woods uses occupational groupings to throw light on which aspects are most closely associated with variations in mortality levels, but is not able to include any measures of income or wealth in his analyses. Instead, he separates the impact of an occupation from the impact of the home environment on life expectancy, by using the infant mortality rate as an indicator of the quality of the home environment. He shows that some occupations, such as file makers[20], miners and inn keepers, experienced a life expectancy as much as five years lower than those of other occupations with similar home environments (that is, similar infant mortality rates). A study of a town in Devon, England, in the late nineteenth and early twentieth century found that day labourers under the age of 45 had an increased risk of dying compared with other occupational categories in the population studied, showing once again the role of occupation (Wall, 2002). Not all research agrees on the importance of socioeconomic conditions for adult mortality levels, however. An examination of mortality in industrial era London (early eighteenth to mid-nineteenth centuries), which examined skeletal remains from cemeteries in areas linked to different social strata, found that lower socioeconomic conditions led to elevated mortality in children but had no apparent impact on adult mortality (DeWitte et al., 2016).

[19] Life expectancy throughout this chapter refers to total life expectancy, not to additional years of life.

[20] File making or cutting was a common occupation at this time, particularly in Nancy. File makers/cutters created files by cutting grooves in the surface of a blanks made from steel (Starmans, 2015).

Within the literature I have consulted, the studies most relevant to my work are those that examine the impact of multiple socioeconomic variables on mortality. These are Woods' work on 'Mortality by Occupation and Social Group' which looks at adult mortality in Victorian England and Wales (Woods, 2000) and Jaadla et al's very detailed analysis of infant and early childhood mortality in early nineteenth century England (Jaadla et al., 2020). Woods' work uses bivariate analysis for groups of occupations, plotting life expectancy against the infant mortality rate. He shows that both the home environment (as proxied by infant mortality) and occupation have an impact on adult mortality (Woods, 2000). Jaadla et al study the impact of occupation, wealth, the home environment (represented by levels of maternal literacy) and geographic effects by parish (Jaadla et al., 2020). This approach is similar to the one I take, although they are examining child rather than adult mortality. I have not found any research which examines the impact on mortality in historic adult populations looking jointly at associations with occupation, income, overcrowding and place, which I am able to do in my dataset.

5.3 Nancy

5.3.1 Historical context

Nancy, a town located in what is now north-east France, is first mentioned in historical records in the eleventh century, following the establishment of a ducal palace there (Boquillon et al., 2008). The town's original function was to serve as the capital of the Duchy of Lorraine and what was to become the *Ville Vieille* (Old Town) grew up around the palace. The city was significantly enlarged in the late sixteenth and early seventeenth centuries by the creation of the *Ville Neuve* (New Town) slightly to the south and outside the old city walls. Lorraine, of which Nancy was the ducal capital, only became part of France in 1736. The *Ville Vieille* and *Ville Neuve* were joined together by the creation of two large squares and additional buildings sponsored by the last Duke of Lorraine, Stanislas, after whom the main square, *Place Stanislas*, is named. By 1766 the population of Nancy was around 27,000.

The city was greatly impacted by the Franco-Prussian war of 1870 (e.g. Sicard-Lenattier, 2002). In 1851 the population of Nancy was still a relatively modest 45,100, but by 1876 this had increased to 66,300. Prior to the war, Nancy was the main urban centre of the *département* (county) of Meurthe which had come into being following the French Revolution in 1789. It was in many respects less important than neighbouring cities such as Metz, which was a military centre, and Strasbourg, which had a large university including its own medical school. All three cities were occupied by German troops during the Franco-Prussian war, but as a result of the peace treaty of Frankfurt in 1871, Nancy was returned to France in 1873. The other two cities became part of the new German province of Elsass-Lothringen, meaning that Nancy was the largest city in north-east France that remained in French hands (Boquillon et al., 2008).

Nancy benefited from the loss of Strasbourg and Metz to Germany to become the new administrative capital of north-east France. As part of the treaty of Frankfurt, citizens of Elsass-Lothringen were given *le droit de l'option* (the right to choose) to remain French and to move to territories controlled by France, and around 130,000 opted to do so. Of these, approximately 9,000 settled in Nancy between 1871 and 1873, and a further 10,000 arrived in the years up to 1914 (Sicard-Lenattier, 2002). Under the terms of the peace treaty, these people could take any of their moveable assets with them when they relocated. These new arrivals included workers, professionals such as lawyers and academics, and factory owners. Various academic faculties also relocated to Nancy from Strasbourg and in 1895 a new university was legally established in the city. The investment of capital transferred from the territories lost to Germany encouraged the industrialisation of what had previously been a medium-sized market town, with new print works, glass works and shoemakers being established within the city. The city became famous for its art nouveau products in glass, including stained glass, with one of the foremost exponents being Emile Gallé (Boquillon et al., 2008).

The increased population in Nancy placed great pressure on housing, with additional accommodation only being provided gradually, although by 1896 the number of dwellings was at more than double the 1872 level (Hecker, 2017). In addition to the increasing industrialisation of the city, a new water supply,

drawing from the upper reaches of the Moselle river, was completed in 1878 and money was borrowed by the city to improve sewage and sanitation. Three tramways were constructed between 1874 and 1894, providing improved access from some suburbs to the city centre (Hecker, 2017). Investments were also made to extend primary education, and, in 1900, to provide secondary education for girls (Picavet, 1899). New roads were laid out, some under the auspices of the city authorities such as Boulevard Lobau and Avenue Anatole France, but a great deal of development was left to private enterprise which meant that it lacked a consistent plan (Collot, 1980). Despite this rapid growth, there was a decline in some of the old businesses such as textiles, which had been dominant in the city as recently as the 1860s. Not all areas benefitted equally from the infrastructure developments, with many properties in the eastern part of the city still not having a domestic water supply by 1900 (Boquillon et al., 2008).

In summary, in the 1890s, Nancy was a vibrant city with a rapidly growing population and a number of flourishing industries. In addition to the migrants for Elsass-Lothringen, people were drawn in from the surrounding rural areas attracted by the availability of work (Boquillon et al., 2008). However, not all inhabitants benefited equally from this growth, with the gains from the public investments into, for example, clean water and tramways only available to inhabitants in certain parts of the city.

5.3.2 Geographical layout of Nancy in the 1890s

The population of Nancy expanded rapidly between the 1870s and the 1890s, increasing from 51,000 in 1872 to 84,000 in 1896, and the number of dwellings more than doubled (Hecker, 2017). This meant that the city grew beyond the original central core, with developments in all directions, converting areas that had previously been rural or semi-rural into new suburbs. Geographically, the city was divided into eight '*sections*' which are administrative areas roughly equivalent to the wards seen in Glasgow. These are shown in Figure 5-1, with the *sections* transcribed onto a present day map.

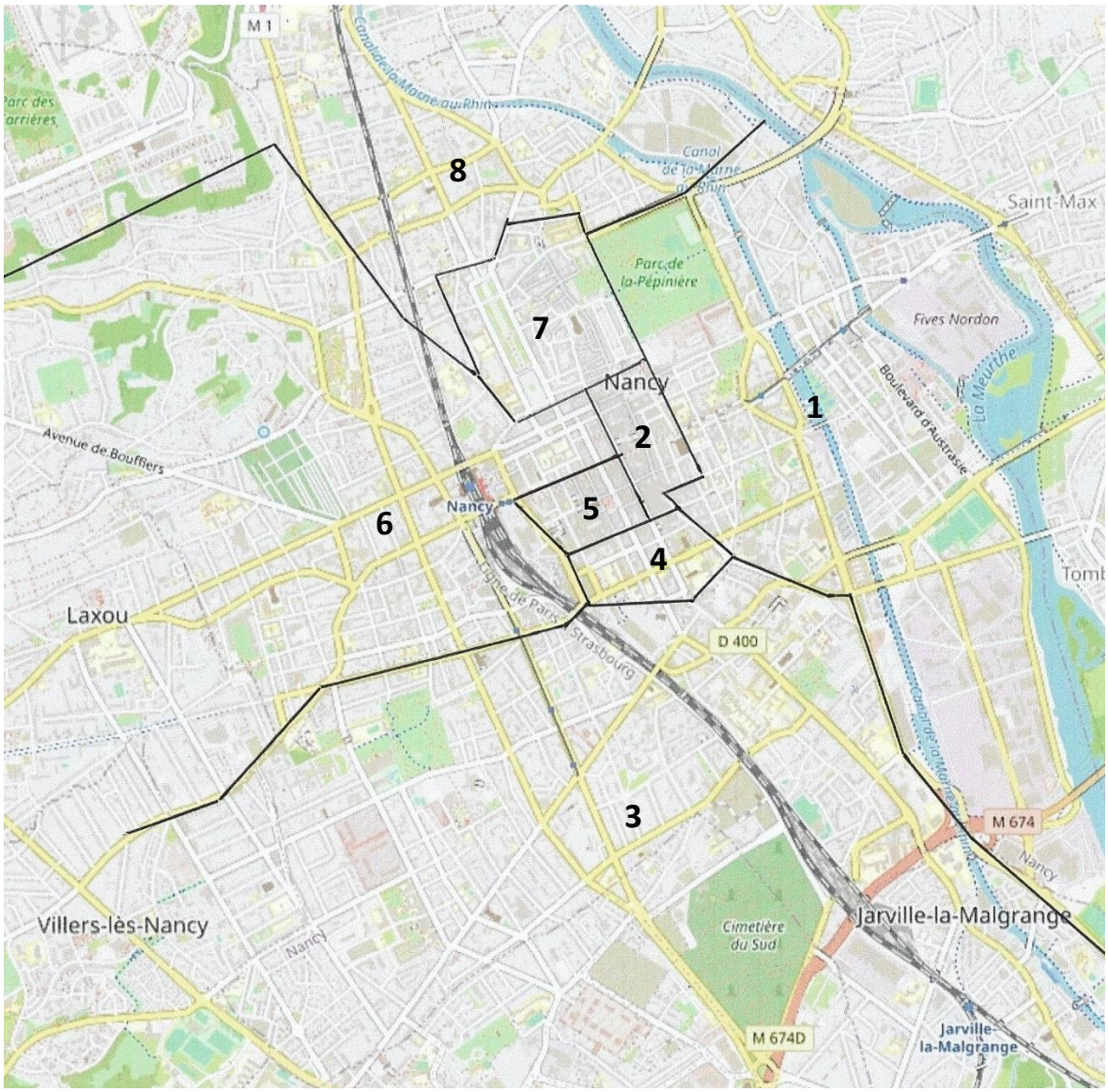


Figure 5-1. Map of twenty-first century Nancy, with *sections* marked as they existed in the late 1800s
Broadly speaking, *sections 2* and *6* were mostly middle class, *section 4, 5* and *7* were mostly working class and the remaining *sections* were mixed. The boundaries have been transcribed manually based on the map '*Plan de Nancy et ses environs' (Christophe and Coure, 1902)* held in the *Archives Municipales de Nancy.*

The key characteristics of the different *sections*, as they were at the end of the nineteenth century, are described by Sicard-Lenattier (Sicard-Lenattier, 2002). *Section* 1 was developed in the late 1800s, extending from the old central parts of Nancy eastwards to the banks of the River Meurthe. It was an area populated mostly by the working class, with a number of manufacturing businesses being established in this previously semi-rural area. *Section* 2 was the core of the 17th century *Ville Neuve*, based around the cathedral and was already fully developed by the mid-1800s; it was occupied by skilled workers and the better

off. *Section* 3, like *Section* 1, underwent a period of rapid expansion in the late 1800s, with larger houses being built close to the railway station and dwellings for skilled workers built further from the town centre.Further to the south, s*ection* 4 was the location of the main city market and other commercial developments. *Section* 5 was a small area between *Section* 4 and the railway line which provided accommodation for a range of people from day workers to professionals. *Section* 6 was also newly developed in the late 1800s but benefitted from roads extended by the city council along which large villas were built to house the growing middle class. *Section* 7 is the area of the *Ville Vieille,* the oldest part of the city which was now made up of a mixture of commercial establishments and the homes of the lower middle-class. Finally, *Section* 8 was a large area stretching to the north of the town which comprised new businesses, their owners and skilled artisans. Despite this broad characterisation of the *sections*, in most areas there was in practice a frequent mixing of the homes of workers and business-owners, as well as business premises (Sicard-Lenattier, 2002).

5.4 The Nancy dataset

5.4.1 Nancy's unique *recensements*

Census data are collected in many countries on a regular basis, but the type and frequency of the censuses vary greatly. In England, censuses are carried out every ten years, with the first modern census being undertaken in 1841. In France, the first modern census was undertaken in 1801 and censuses were generally run every five years, for years ending in 1 and 6, up to the Second World War. In addition to these mandatory five-yearly censuses, the town of Nancy undertook a detailed census every year from 1795 to 1991. Personal communications with staff at the *Archives Municipales de Nancy* identified no clear motivation for undertaking this relatively arduous work so frequently. Those collecting the census information made efforts to ascertain who did or did not have the legal right to reside in Nancy, so this may have been one purpose of their work. The census also provided advantages in terms of maintaining accurate electoral lists (Bedez, 2023). The number of rooms and annual rents payable for most properties were recorded from 1880 onwards, which would

have been a valuable source of information for taxation purposes, but this does not explain why the practice of undertaking annual censuses began at such an early date.

5.4.2 Data sources and variables

Data collection for the Nancy dataset was undertaken both on-line and in the *Archives Municipales de Nancy,* located in the city of Nancy. The main documents consulted were the registers of deaths (*Registres des* décès), which recorded every death within the city, and the censuses (*Recensements)* which were undertaken annually. The death registers for 1792-1942 are available on-line. The censuses are only available on-line for every fifth year (1895, 1900, etc). For other years, the original documents needed to be consulted within the archives. Both the death registers and the censuses for the years of interest were hand-written, sometimes in pencil, which at times made accurate transcription challenging. Practice in reading this type of documentation improved accuracy, as did advice from the staff in the archives, who also assisted with abbreviations. Nevertheless, some transcriptions were incomplete due to the illegibility of the original document.

In order to examine my research questions in relation to the death of the male head of household (the work of this chapter and Chapter 6), I focussed on married men who died between the ages of 26 and 49 (inclusive) from 1st July 1895 to 30th March 1897. The ages were selected to maximise the chances of the man having a family living at home, and so being the family breadwinner. The start date was selected to ensure that the earliest of the 1895 deaths could be found in the 1895 census. Although the censuses are marked by year, closer examination suggests that data collection commenced around April, meaning that the last census entry for a person who died in the early part of a year (say January to March) would be observed in the census of the previous year. July was chosen as the cut-off date for deaths in 1895 to ensure the best chance of finding the individual in the 1895 census. The end date was chosen once a sufficiently large sample (around 190 individuals) had been found to allow initial analysis. My intention is to increase this sample size in the future. This data

collection was undertaken as part of a joint project with other collaborators (see e.g. Stewart et al., 2024).

Details of the deceased breadwinner were transcribed from the death registers and cross-matched with the census for the relevant year. If a match could be found, details were transcribed for that year and the family was followed in subsequent censuses up to 1898. The date of death provided the base point at which each family of the deceased is examined – this is the point when the initial record is created and is when the circumstances of the family changed. By following these families, I have thus created a unique longitudinal dataset of households in Nancy in the mid-to-late 1890s, who have the specific characteristic of having experienced the death of the male head of household.

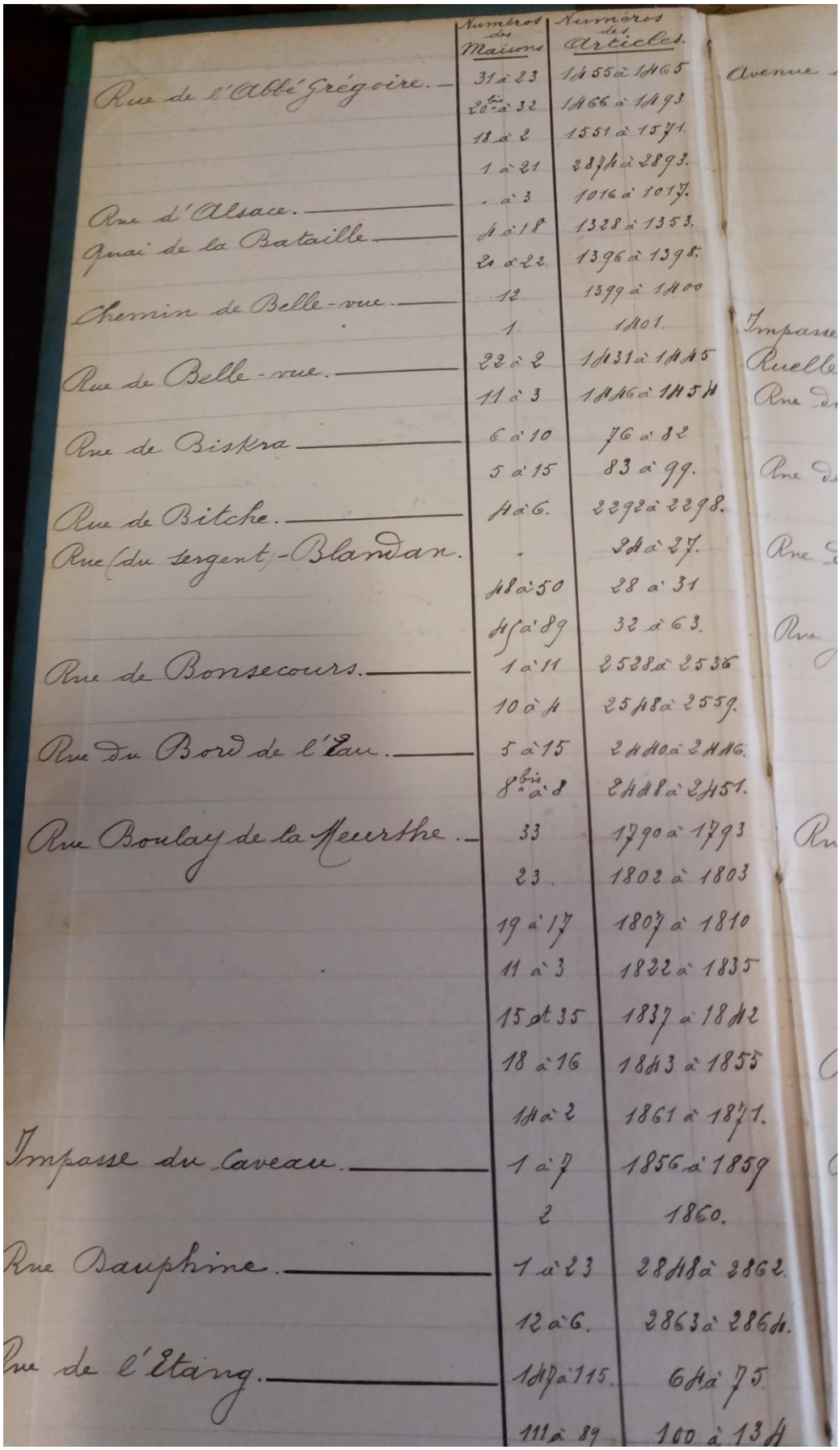
All data were transcribed by hand. This process was time-consuming and may have led to errors including mistakes in transcription or the misreading of abbreviations; however, it also allowed me to accustom myself to the handwriting and to identify patterns and cope with inconsistencies. In addition, as the data-transcriber, I have needed to make choices such as how long to spend searching for a particular record before deciding a match could not be found, or whether a person in one record was truly the same person in another record despite, e.g. differing spelling of names. As is pointed out in Abramitzky, such issues mean that a dataset created by one transcriber may not be identical to a dataset created from the same sources by a different transcriber. Some arguments suggest that an automated approach is preferable if it can be devised (Abramitzky et al., 2020), but this was not feasible using the sources available, where the majority of the data were entered as free-form text.

In order to trace a deceased person in the census, the address at which they lived needed to be found. The address was provided in the register of deaths, but not the *section* in which the address could be found. Maps and street lists provided within the *Archives* usually made it possible to identify which street was in which *section(s)*. This did not, however, help in finding the street within the census volumes. Census data were recorded by the eight geographical *sections* of the city, and each *section* had between two and nine volumes of census data associated with it. The volumes were arranged in order of the

streets which were followed by the census-takers, so are not in alphabetical order. Fortunately, in 1896 each volume of the *cadastre*[21] included an index of (usually) all the streets contained in that *section*, complete with house numbers (see Figure 5-2). By referring to this, I was able to trace the address of the deceased person to the correct volume of the census (also sometimes referred to as a population register). Each record for a family unit was marked numerically in the margin of the census and this number was used for cross-referencing within the censuses; I call this number the census number. The compilers of the censuses also used these numbers to show where families had moved from and to, see below. Each record, once found in the census, can therefore be identified by the year, the *section*, the volume and finally the census number. It can be seen from this description of the process that the time involved for checking the census for even one year was considerable.

The records of 190 married men in the specified age group were found in the death registers and of these, 164 (88%) were traced in the censuses for at least one year. Of those who could not be traced, one address was found to be outside the Nancy census area and so was dropped, and in twelve instances the deceased could not be found at the address given on the death certificate. There was no obvious reason why these deceased should have an incorrect address: for example, if the death register information was provided by hospital staff rather than family then this error might be expected to be more common, but of these twelve only three are shown as notified by hospital staff, with the remainder being relatives or friends. In addition, thirteen addresses could not be found in the censuses, for example because the street or house number could not be located. Due to time pressures, these had to be put aside. There is no reason to assume that these thirteen were atypical of the sample as a whole, as they are spread out across seven of the eight *sections*[22]. If the deceased person could not be found in at least one census, they were dropped from the sample, as it was not possible to collect further information from available sources.

[21] The *cadastres* are annual lists of properties in a municipality.
[22] None of these appear to be in *Section* 2, but this was a small *section* and had very few individuals in the sample.



	Numéros des Maisons	Numéros des Articles	
Rue de l'Abbé Grégoire.	31 à 23	1455 à 1465	Avenue
	20bis à 32	1466 à 1493	
	18 à 2	1551 à 1571.	
	1 à 21	2874 à 2893.	
Rue d'Alsace.	. à 3	1016 à 1017.	
Quai de la Bataille	4 à 18	1328 à 1353.	
	20 à 22.	1396 à 1398.	
Chemin de Belle-vue.	12	1399 à 1400	
	1	1401.	Impasse
Rue de Belle-vue.	22 à 2	1431 à 1445	Ruelle
	11 à 3	1446 à 1454	Rue d
Rue de Biskra	6 à 10	76 à 82	
	5 à 15	83 à 99.	Rue d
Rue de Bitche.	4 à 6.	2292 à 2298.	
Rue (du sergent)-Blandan.	.	24 à 27.	Rue
	48 à 50	28 à 31	
	45 à 89	32 à 63.	Rue
Rue de Bonsecours.	1 à 11	2528 à 2536	
	10 à 4	2548 à 2559.	
Rue du Bord de l'Eau.	5 à 15	2440 à 2446.	
	8bis à 8	2448 à 2451.	
Rue Boulay de la Meurthe.	33	1790 à 1793	Ru
	23.	1802 à 1803	
	19 à 17	1807 à 1810	
	11 à 3	1822 à 1835	
	15 et 35	1837 à 1842	
	18 à 16	1843 à 1855	
	14 à 2	1861 à 1871.	
Impasse du Caveau.	1 à 7	1856 à 1859	
	2	1860.	
Rue Dauphine.	1 à 23	2848 à 2862.	
	12 à 6.	2863 à 2864.	
Rue de l'Etang.	147 à 115.	64 à 75.	
	111 à 89	100 à 134	

Figure 5-2. Example of an index from the 1896 Nancy *cadastre*
Section 3, showing the street names, house numbers (*Numéros des Maison*) and cadastre numbers (*Numéros des Articles*). Original held in the *Archives Nationales de Nancy*. Copy courtesy of the *Archives Nationales de Nancy*.

The Nancy *recensements* proved to be a rich source of information. Where possible, the following data were transcribed: full name and age of the breadwinner, wife and any other household members; relationship of other members to the breadwinner; occupation of the breadwinner and other individuals for whom occupation is listed; type of accommodation (e.g. house, apartment, etc); number of rooms and sometimes whether there was a kitchen or toilet (*cabinet*); and rent paid. In addition, if the household had moved recently it was noted '*de la …*' (from) and the relevant census number and *section* provided. Similarly, if the household had moved after being entered into the census then the entry was crossed out and information provided as to the new location (*à la …*).

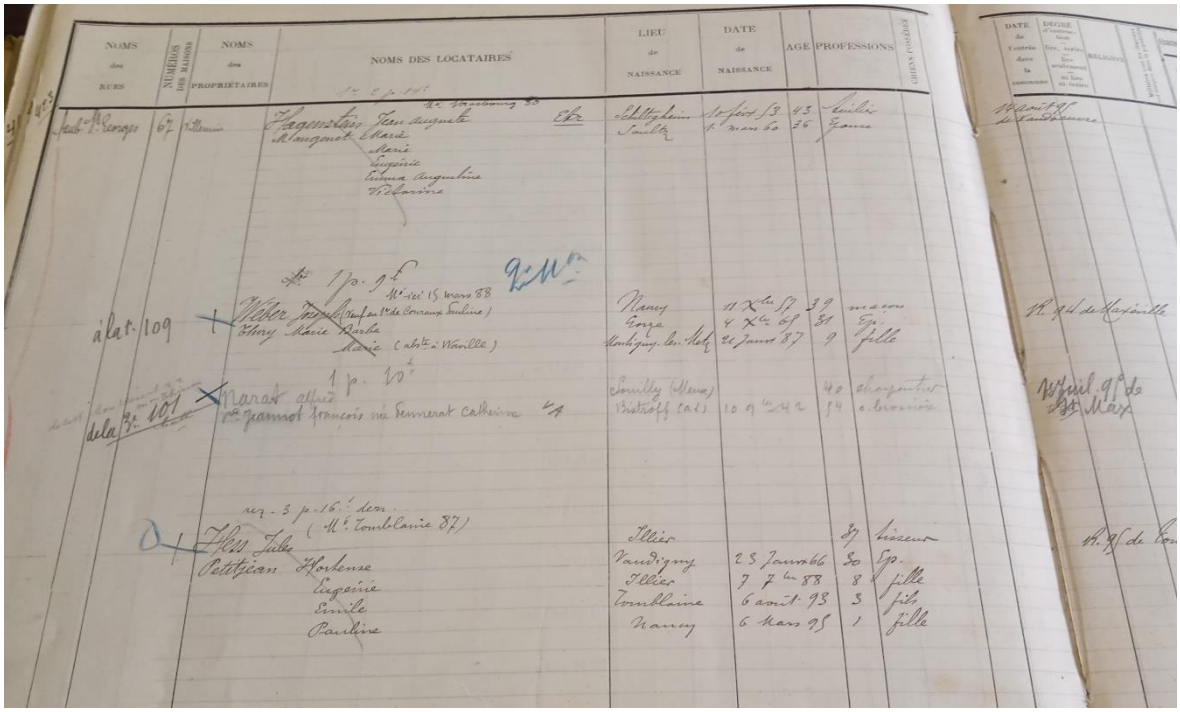


Figure 5-3. Example of a census entry form the Nancy *recensement*
The census number is shown in the margin on the extreme left, with the street and house number and the details of various households clearly listed. Example from 1896, *Section* 1, Volume 2. Note that the household Weber is crossed out and marked as having moved '*à la 1e 109'*, which means they can be found at census number 109, again in *Section 1*. Original held in the *Archives Municipales de Nancy*. Copy courtesy of the *Archives Municipales de Nancy*.

The presence of the information on where a family had moved from and, more importantly, to, provided the opportunity to follow households over a number of moves/years and was key to the creation of this dataset. The wife was usually entered under her birth name until she became a widow, when she was listed as *Veuve* (widow) followed by the name of her late husband, with her birth name

following. Typical census entries are shown in Figure 5-3. The majority of data were entered on the left-hand page, with only the first column of the right-hand page used. A list of all data included and an image of both pages in full is included in Appendix 8.4.1, Figure 8-9. Households were made up of a combination of husband, wife, children, step-children, other family members, servants and lodgers. Not all households included all types of individuals. This information on household members allowed the calculation of additional variables such as number of children, persons per room and rent per capita. It was also possible to identify whether the head of the household owned the property, in which case the name would be written across the two columns *Noms des Proprietaires* (names of owners) and *Noms des Locataires* (names of renters). It was also sometimes possible to identify if the property was owned by another member of the same family by comparing the name of the head of household or wife in the *Noms des Locataires* column with the name of the owner in the *Noms des Proprietaires* column.

There were different types of properties shown in the censuses. A family might, rarely, occupy a whole house. More commonly, they occupied an apartment, or an apartment co-located with a business. Other types of accommodation listed are shacks (*baraques* or *constructions en bois)*, or furnished accommodation often let out for short periods of time (*garnis)*. Roughly speaking, those who lived in an entire house would be among the better off and those in *baraques* or, in particular, in *garnis* would have been among the poorest. Rents, which are annual, are never provided for the latter, indicative of the transitory nature of this accommodation.

A number of additional data variables were also created. A binary category was constructed showing if it was likely that the family business could be continued by the wife following the husband's death; all small businesses such as cafés, restaurant, grocers, bakers, etc, were classified in this way. A variable was created to show whether the wife remarried and, if so, how soon after the husband's death. Variables were also created for whether any other household members died and, if so, how soon after the breadwinner's death. The datasets used in this thesis and the code for the analysis are lodged at 10.5281/zenodo.10817542.

5.4.3 Occupational Classifications

I have based the occupational classifications in my dataset on work undertaken by van Leeuwen and Maas which uses the Dictionary of Occupational Titles (DOT) and the Historical International Standard Classification of Occupations (HISCO), and reworks these into a new historical and international social class scheme, which they call HISCLASS (Van Leeuwen and Maas, 2011). Their work classified occupations into twelve classes, going from level 1 (highest status, e.g. large landowner, person with private income) to level 12 (gardeners, unskilled farm workers), and includes 1,675 occupations as categorised in HISCO. The classifications were initially suggested by the researchers themselves and were then checked by a panel of experts and amended if the majority of the panel agreed that changes were required.

Occupations in my dataset were transcribed from the Nancy censuses for all members of the household for whom they were recorded. The occupations were then classified according to two systems: DOT and HISCLASS. HISCLASS is considered more accurate as it has been validated by experts (Van Leeuwen and Maas, 2011). HISCLASS classifications also generally appeared more correct than those in DOT. For example, DOT classified Administration Manager as level 1, which is the very highest category, but HISCLASS allocated it to level 2, which contained such jobs as accountant, with which it seems more aligned; DOT classified Retail Sales Person as level 9, indicating a low level of skill, but HISCLASS allocated it to level 5, which is a category containing office clerks, with which it seems more similar. HISCLASS occupational categories have therefore been used in my work.

Examples of the sort of occupations listed in the Nancy censuses and how these were classified are provided in Table 5-1, with further details being supplied in Appendix 8.4.1, Table 8-10. To facilitate analysis, HISCLASS classifications are often grouped into a smaller number of categories, for example Dribe and Helgertz divided them into four groups[23] (Dribe and Helgertz, 2016). Due to the relatively small numbers in some of the categories in the Nancy sample (see

[23] They actually have five groups but one is ‘farmers’ which is not relevant to my sample.

Table 5-1), I have used three broader categories: high, which includes classifications 1 and 2, medium which includes classifications 3-8 and low which includes classification 9-12.

Table 5-1. HISCLASS occupational status classifications

Classification	General Description	Number in head of household sample
1	Higher managers	5 deceased
2	Higher professionals	11 deceased
3	Lower managers	8 deceased
4	Lower professionals and clerical and sales personnel	26 deceased
5	Lower clerical and sales personnel	12 deceased
6	Foremen	1 deceased
7	Medium skilled workers	67 deceased
8	Farmers and fishermen	1 deceased
9	Lower skilled workers	17 deceased
10	Lower skilled farm workers	None
11	Unskilled workers	14 deceased
12	Unskilled farm workers	1 deceased

(Van Leeuwen and Maas, 2011)

5.4.4 Missing and imputed values

Data for certain variables are missing in the records I was able to consult. For example, no rent is provided if the household lived in a *garni,* which was short-term furnished accommodation similar to the lodging houses which were occupied by itinerant workers in the UK at this time (e.g. see Fraser and Maver, 1996, on lodging houses in Scotland). I thus impute a value of the rent for households living in *garnis* at 1f[24], to indicate that it was probably very low. The imputed rent for a *garni* is kept at 1f for all years as there is no indication of rental inflation in the sample, with households who do not move keeping the same rent for three or even four years. The lowest recorded rent for any of my sample was 2f. Six households of deceased individuals lived in *garnis*. Similarly, a rent is very rarely provided if the family lived in a shack, possibly because these were constructions that were built by the occupants. Three families of deceased

[24] The abbreviation 'f' is used to represent *francs,* the currency in use in France at this time.

men lived in shacks in the year of death. Sometimes, even if the family lived in an ordinary apartment, no rent is written down.

In cases where no rent or number of rooms was provided, I used the following system to impute a value. I firstly checked for rent or rooms for the same property in the previous year. If available, this was used. If this was not available, I checked for rent or rooms for the same property in following year. If available, this was used. If this was not available, I checked the rent of a nearby property, matching as closely as possible the number of rooms, presence or not of kitchen or toilet and position of accommodation (rents vary by floor and whether at the back or front of a property). When imputing the number of rooms, I checked for rooms in a nearby property, matching as closely as possible the rent provided and the position of the accommodation.

In the year of death, this approach was used for 13 properties. For some properties, rents as written on the census documents include the business premises at the same address, and in these cases the domestic rent has had to be imputed by making comparisons with domestic rents for nearby properties, as above. In the year of death, this was the situation for 25 properties of deceased men.

The number of rooms also had to be imputed when they are not provided in the censuses. The number of rooms for people living in *garnis* is never provided, which makes sense as this may well be shared accommodation. In order to indicate that less space per person is likely to be available here, the number of rooms is considered to be 0.5. Rooms in a shack are also rarely provided, and if not available these are imputed as one room. Rooms for other accommodation also had to be imputed for four records in the base year, using the process outlined above.

One final missing variable is cause of death for each of the 164 individuals in the sample. Cause of death was not one of the required pieces of information when the civil registration of births, marriages and deaths was first introduced in France in 1792, (INED, 2023). Cause of death statistics were released at the municipal level (as opposed to the individual level) in certain government

statistical releases, such as *Statistique sanitaire des villes de Frances et d'Algerie* (Republique Francaise, 1891). Even today, cause of death is not shown on the administrative portion of a death certificate, the details of which are processed by INSEE (*Institut National de la Statistique et des Etudes Economiques)*, but is included in a separate sealed medical portion of the certificate which is sent to a different statistical agency, INSERM (*Institut National de la Santé et de la Recherche Médicale)*. In other words, the cause of death information is explicitly separated from the mortality records and additional work would be needed to align it with, for example, different geographical boundaries, as is discussed briefly by Bonnet and d'Albis (Bonnet and d'Albis, 2020). It has therefore not been possible to include any analysis of cause of death in the work on Nancy.

5.5 Description of the Nancy dataset

5.5.1 General characteristics

As described in the Section 5.4, the data sample to be used included all married men between the ages of 26 and 49 years inclusive, who lived in one of the eight *sections* that made up central Nancy, who died between 1st July 1895 and 30th March 1897 and who could be found in the census at the address as given in the register of deaths. This initially provided a sample of 164 households. On closer inspection, three records were found to be anomalous, with the recorded occupation not matching the rent paid. All three rents were far higher than could be explained by the occupation(s) of the tenants, so the family must either have had other financial resources or have received support from elsewhere. For example, Francois Krier was a day worker (HISCLASS 11) but managed to pay a rent of 300 francs, which is higher than the mean rent for the sample. As details relating to other likely sources of income are not available, these records were dropped in the main analysis, but included as a robustness test. The key descriptive statistics of the remaining 161 households are shown in Table 5-2.

Table 5-2. Descriptive statistics for the 161 deceased men and their households in the Nancy sample

Variable	Minimum	Maximum	Mean	Standard deviation
Age at death	26	49	40.1	5.80
Number of household members	2	12	4.6	2.27
Number of children	0	8	1.90	1.88
Number of servants	0	2	0.07	0.29
Number of lodgers	0	2	0.12	0.35
Number of rooms in dwelling	0.50	6	2.31	1.16
Persons per room	0.50	11	2.52	1.89
Rent in francs (excluding business premises)	1	1,800	290	332

Notes: Number of rooms has been imputed for four households. Rent has been imputed for 23 households without business premises and 25 households with business premises.

The age at which the men in my sample died is distributed across the age range of interest, with at least one dying at each of the possible ages between 26 and 49 years, except for age 27 (Figure 5-4). It appears that, within the sample, more men die at an older age, although in fact deaths peak at age 47 and fall thereafter. I cannot say for sure if this means the probability of dying increased with age for my sample, as I do not have information on the total male population of Nancy at each age. Looking at life tables for France 1897-98, male mortality levels did increase over this age range, going from around 8 per thousand at the age of 30 to around 12 per thousand population for those in their late forties (Mesle and Vallin, 1991). It seems likely that the same was true for my Nancy sample.

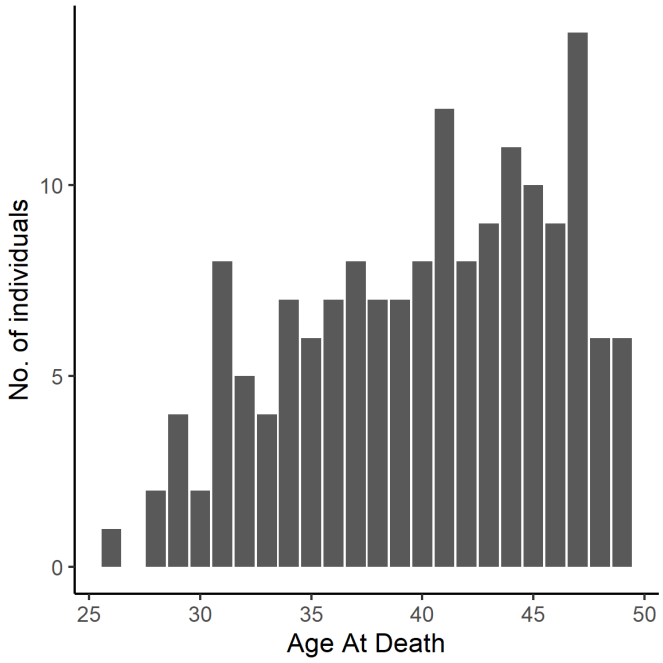


Figure 5-4. Age at death of the 161 heads of household in the sample

The minimum household size was two members, being the husband and wife. Forty-eight of the households had no children living at home, with 86 households having between one and three children and 12 having six or more children (Figure 5-5); the average household size, including servants and lodgers, was 4.6 people and the average number of rooms per dwelling was 2.3.

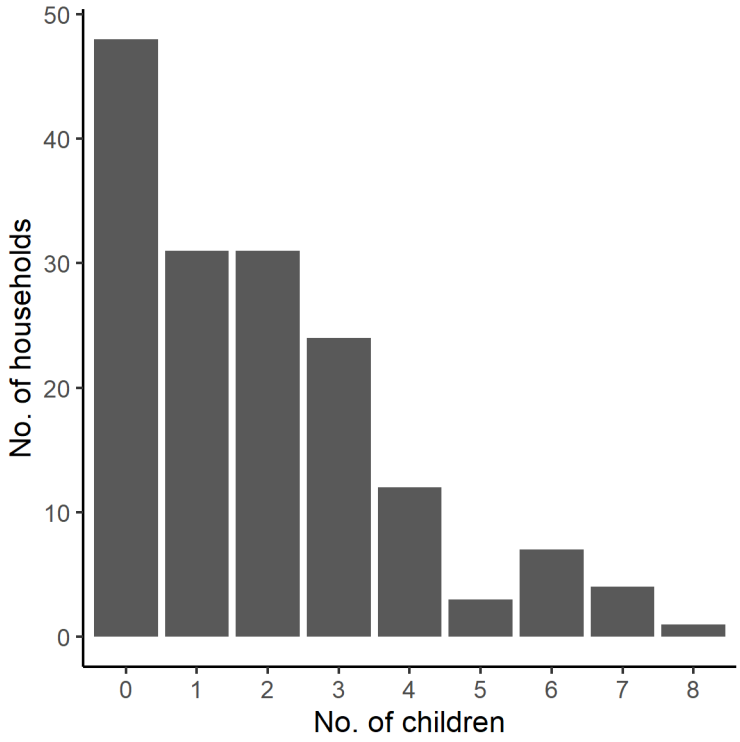


Figure 5-5. Number of children living at home
Data are for the 161 families in the sample, in the year the head of household died.

Domestic rent paid by a household varied between 1f (imputed for *garnis*; the lowest rent for any other accommodation is 2f) and 1800f. The distribution of rents is shown in Figure 5-6, showing a long right-hand tail, as is often found in income-related distributions. Although the mean rent was 290f, the median rent was 240f, and the majority of households paid a 'low' rent of less than 300f with 89 households (55%) falling into this bracket[25]. Only seven households paid rents of 1000f or more. In my analysis I use rent as an indicator of income, on the basis that households with a higher income are probably more willing and able to

[25] Kesztenbaum and Rosenthal define those paying rents below 300f as 'the poor' in their 2016 paper on Paris, 1880-1913 (Kesztenbaum and Rosenthal, 2016).

pay a higher rent[26]. Using rent in this way may underestimate the disparity in income, as current-day poorer households are known to pay a higher proportion of their income in rent (e.g. Desmond and Wilmers, 2019), and this may also have been the case in nineteenth century Nancy. I will not attempt to correct for this issue.

The Gini coefficient calculated on rent in the year of death of the breadwinner is 0.56. Current day France has a Gini coefficient of 0.45 when calculated on income before tax and public transfers and 0.3 after tax and public transfers (OECD, 2023). The 1890s Gini coefficient is probably best compared to that of income after tax and transfers, and shows us a population living with high levels of inequality compared to current times. This would lead us to expect, in line with research on the impact of income inequality on mortality (e.g. Wolfson et al., 1999), that there would be a marked difference in my sample in mortality between the richer and poorer households.

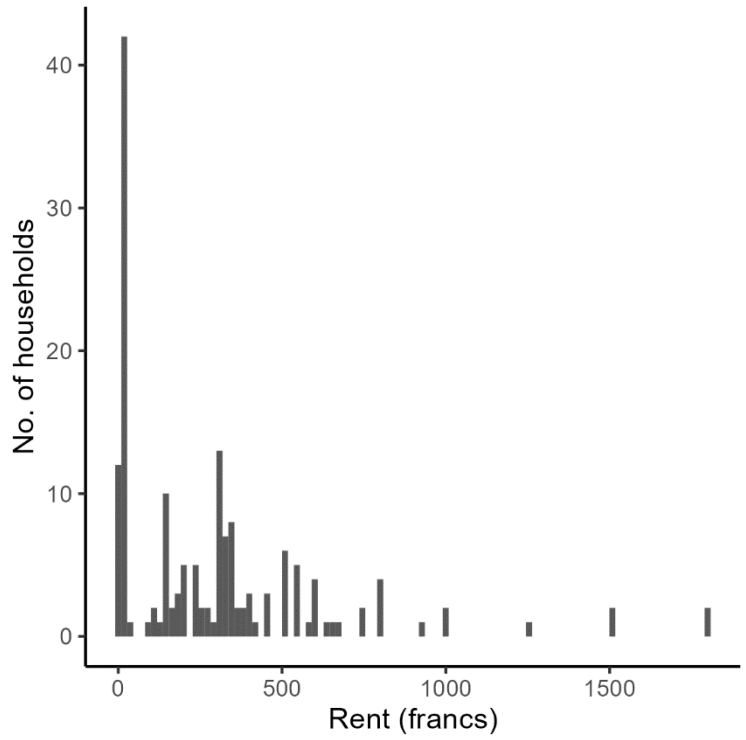


Figure 5-6. Rent paid by the 161 households in the year the breadwinner died

[26] It should be noted that rents at this time in France probably accounted for around a third of household expenditure, a smaller proportion than food and fuel (U.S. Department of Commerce and Labour, 1909).

The 161 members of the sample were analysed according to their occupation at date of death, using the HISCLASS system for identifying historical status, see Figure 5-7(a). The largest single grouping is class 7, which contains 67 individuals. This category includes many artisans and skilled manual workers such as butchers, bakers, painters, file makers and shoemakers (shoemakers are the most numerous in this sample, being 18). The next largest group are those classified at level 4, which includes shopkeepers and café owners. The least skilled workers, classified as 11, are mostly *journaliers (*day workers) but also include *manoeuvres* (labourers) and errand and message boys. There is only one individual classified as 12, a gardener. This sample seems to be typical of what you would expect from an industrial city such as Nancy had become, as discussed in Section 5.3.1: it was predominantly a city of artisans.

As discussed in 5.4.3, I have grouped occupational status into three categories: high, medium and low. By far the largest group is those defined as of medium occupational status (Figure 5-7(b)). A table of example job titles and their classifications is given in Appendix 8.4.1, Table 8-10.

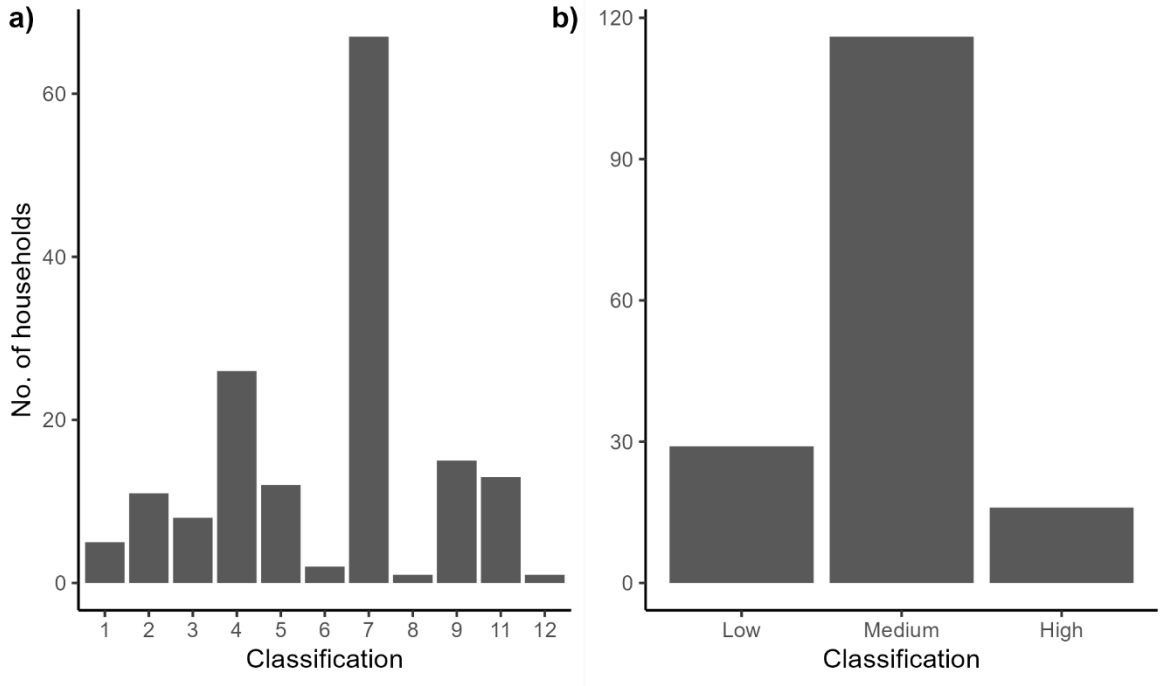


Figure 5-7. Bar chart showing the distribution of the occupations of the 161 deceased men
Classification is for occupation at date of death: a) based on the HISCLASS system, where 1 is the highest status and 12 the lowest; and b) grouped into low, medium and high status.

Deaths of the 161 men in the sample also varied over the months of the year; see Figure 5-8(a). Most deaths in urban France at this time occurred in the colder months, probably due to higher deaths from respiratory tract diseases which are found generally in autumn and winter (Rau, 2007). When deaths are grouped into colder (Autumn-Winter) and warmer (Spring-Summer) months, the pattern of deaths in my sample can be seen even more clearly (Figure 5-8(b)).

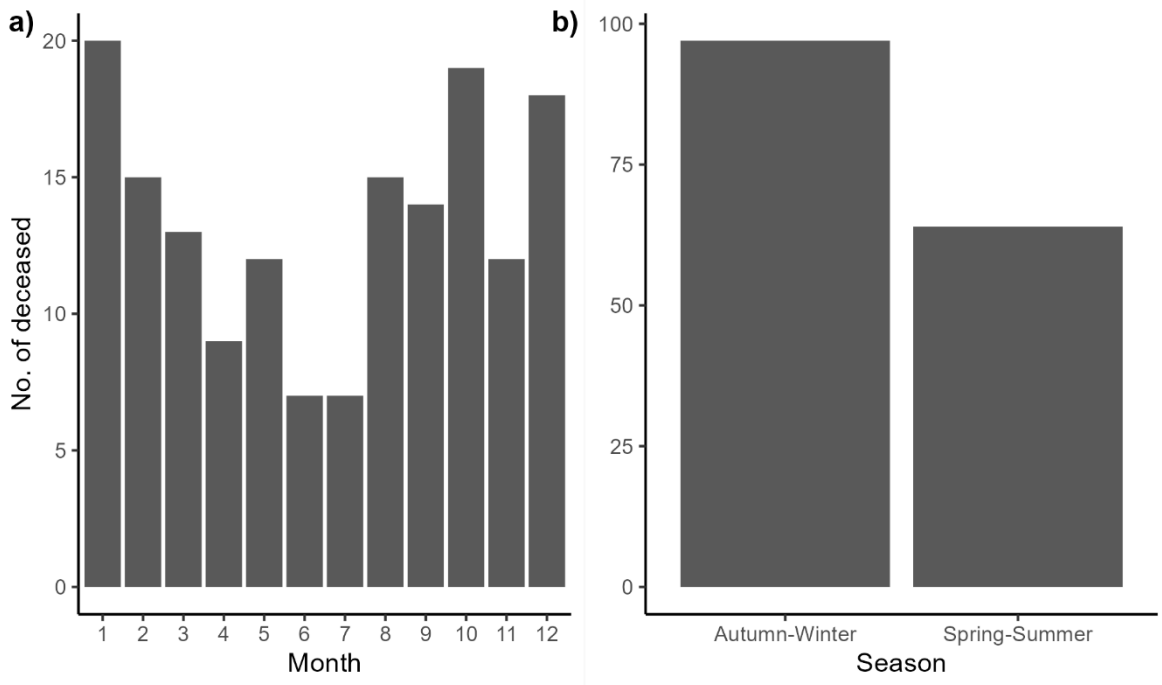


Figure 5-8. Seasonality of deaths in the sampled of 161 heads of households
Data shown by a) deaths by month and b) deaths grouped to show seasonal differences, with Autumn-Winter consisting of months 10-12 and 1-3 (October to March) and Spring-Summer consisting of months 4-9 (April-September).

5.5.2 Variation between *sections* of Nancy

The 161 households in my sample were spread across all eight *sections* of the city of Nancy. An overview of the distribution of the households between the *sections* and the rents paid in each *section* is given in Table 5-3. The very poorest people, who lived in *garnis* (rent imputed as 1f), were concentrated in *Sections* 1 and 7. Only *Sections* 2 and 4 had no one in my sample paying a rent of less than 10f, which would be a very low rent indeed. The household paying the highest domestic rent of 1,800f per annum resided in *Section* 6, but in this same *section* there was a household paying only 2f per annum. The *sections* with the

largest numbers of families in my sample were 1, 3 and 8, newer areas to the east, south and north of the city centre.

Table 5-3. Details of number of households in each *section*

Section	Number of households	Mean Rent	Median Rent	Minimum Rent	Maximum Rent
1	35	150	18	1	550
2	6	544	588	16	1000
3	36	291	295	8	800
4	13	373	168	92	1500
5	12	206	172	5	500
6	18	597	350	2	1800
7	9	271	30	1	1250
8	32	222	200	5	600

Notes: The table shows the number of households, plus the mean, median, minimum and maximum rents paid in francs in the year of death of the head of household.

When considering the occupational status by *section*, using the full range of 12 categories given in HISCLASS, I found that people of higher occupational status (indicated by a lower number) were more likely to live in *Section* 2, the centre of the *Ville Neuve*, or *Section* 6, a newer area to the west of the old centre; both these areas had the lowest median value for occupational status (Figure 5-9). This fits in with the description of the *sections* provided earlier, which suggested that *Section* 2 was the well-to-do area around the cathedral and that *Section* 6 was home to many large villas that were built along its new roads (Section 5.3.2). In all other *sections* the median occupational status was 7, reflecting the large number of people who fell into this classification.

The age at death of the head of household varied to some extent by which *section* the man lived in, as can be seen in Figure 5-10. The median age of death was highest in *Section* 2 and lowest in *Section* 7, but as can be seen in the descriptive statistics these two *sections* contained small numbers of deceased, so one additional death of an older or younger person could skew the results.

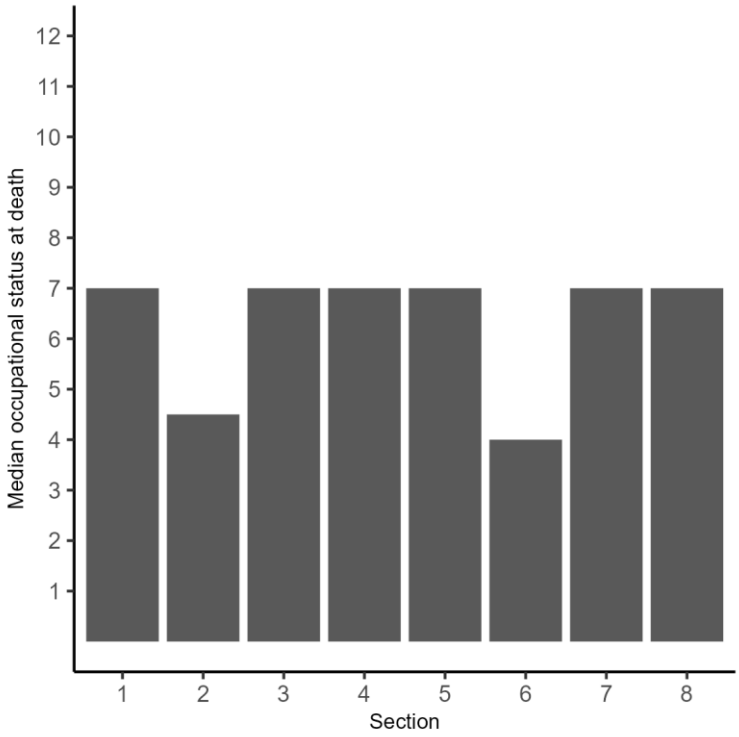


Figure 5-9. Bar chart showing median occupational status at date of death, in the eight *sections*
High occupational status is represented by a lower number.

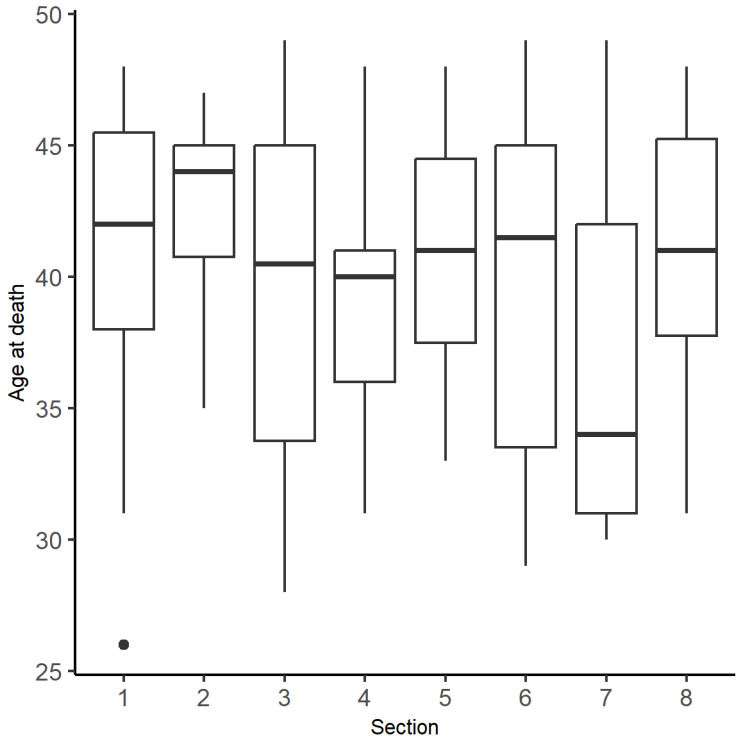


Figure 5-10. Boxplot showing median age by *section*
Also shown are first and third quartiles and highest/lowest values not more than 1.5 times the inter-quartile range, for the eight *sections* of central Nancy.

Looking at the details discussed above, a pattern begins to emerge with regard to occupational status and the different *sections* for the breadwinners in my sample. These differences become more pronounced if I divide occupational status into three broad groups, high, medium and low, and look at the spread of occupational status and rents within each *section*. *Sections* 2 and 6 had no households with a low occupational status deceased and no families living in *garnis,* which means they had no one paying the lowest imputed rent (Figure 5-11). These *sections* appear to represent the better off areas of Nancy, both in terms of occupational status and income (as proxied by rent). *Section* 6 had the highest mean rent, but *Section* 2 had the highest median rent (see Table 5-3). *Section* 2 is used as the reference category when comparing geographical areas.

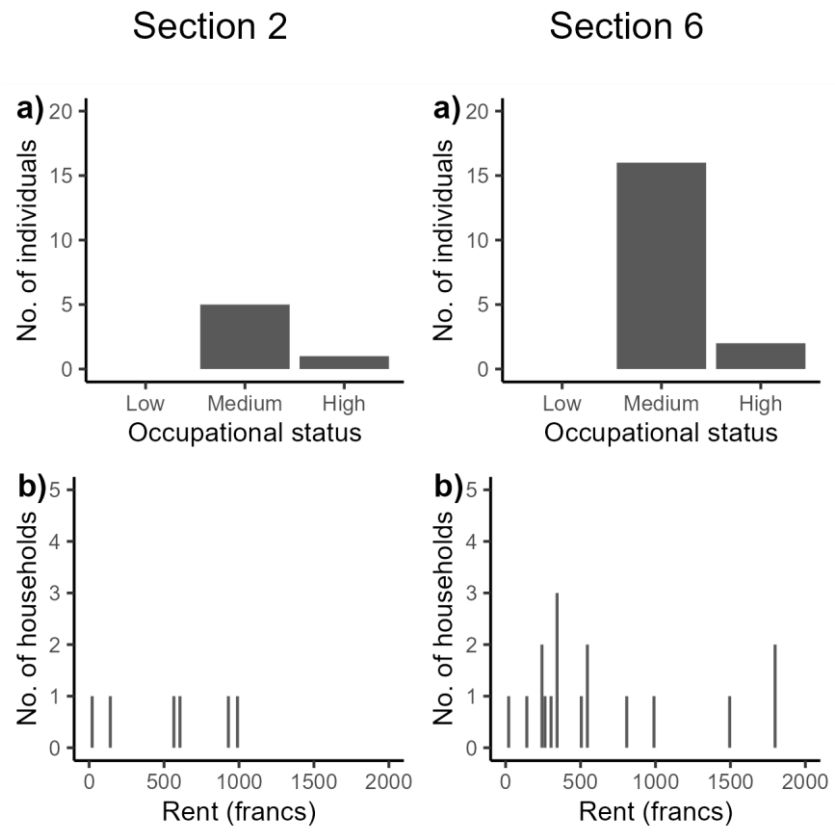


Figure 5-11. *Sections* 2 and 6, occupational status and rent
These two *sections* have no low occupational status households. Plots show a) the occupational status of the breadwinners and b) the annual rent.

Sections 4, 5 and 7 had no households where the breadwinner was of high occupational status. Although *Sections* 7 and 4 have a small number of households paying rent in excess of 500f, most rents are below 300f with *Section* 7 having four households living in *garnis*. These three *sections* appear to have

rents concentrated at the lower end, which might be expected if the breadwinners were of medium or low occupational status (Figure 5-12).

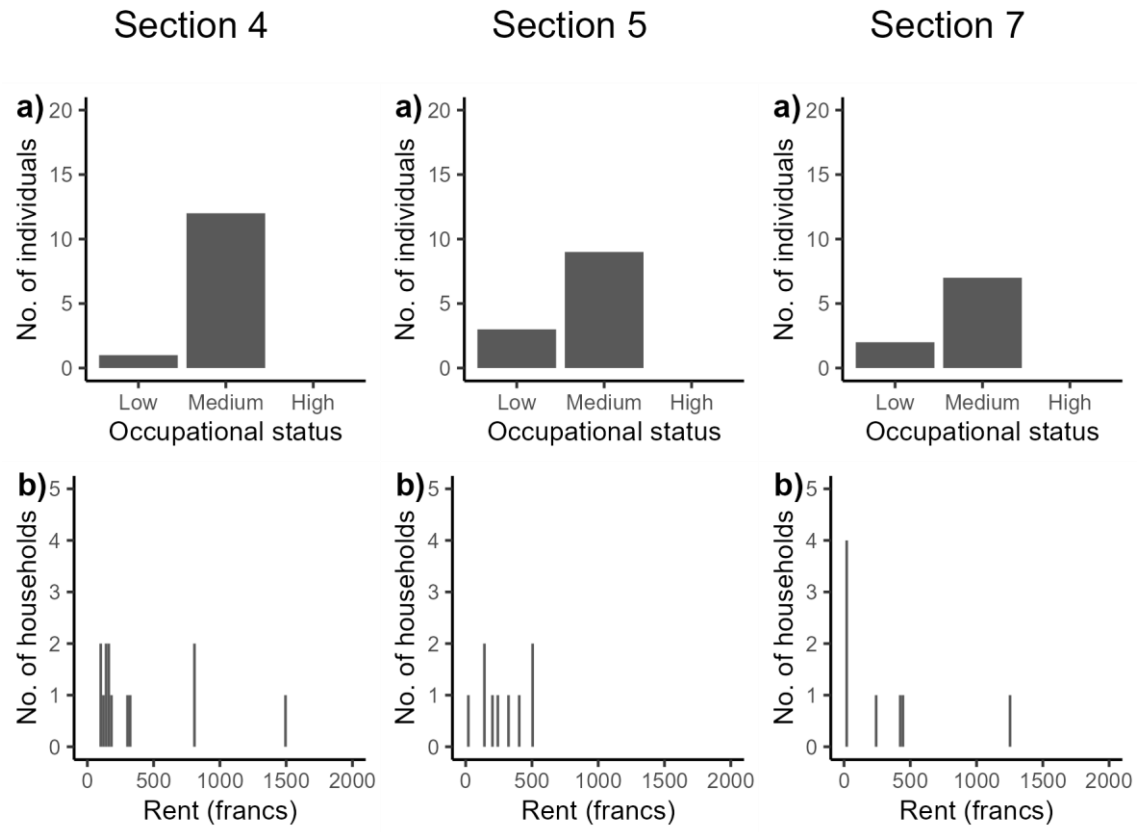


Figure 5-12. *Sections* 4, 5 and 7, occupational status and rent
These s*ections* have no high occupational status households. Plots show a) the occupational status of the breadwinners and b) the annual rent.

Only *Sections* 1, 3 and 8 contained households in all occupational statuses. Although all three *sections* had breadwinners with high occupational status, there are no very high rents paid (i.e. in excess of 1,000f). *Section* 1 has the lowest rents, which included two *garnis* (Figure 5-13).

Childless couples were spread across all *sections*, as were households with servants. However, households which included lodgers, who were often employees in the family business, were heavily focused in *Sections* 1 and 8, both of which *sections* contained six such households. Sicard-Lenattier also identified *Sections* 1 and 8 as areas where many businesses were located at this time (Sicard-Lenattier, 2002).

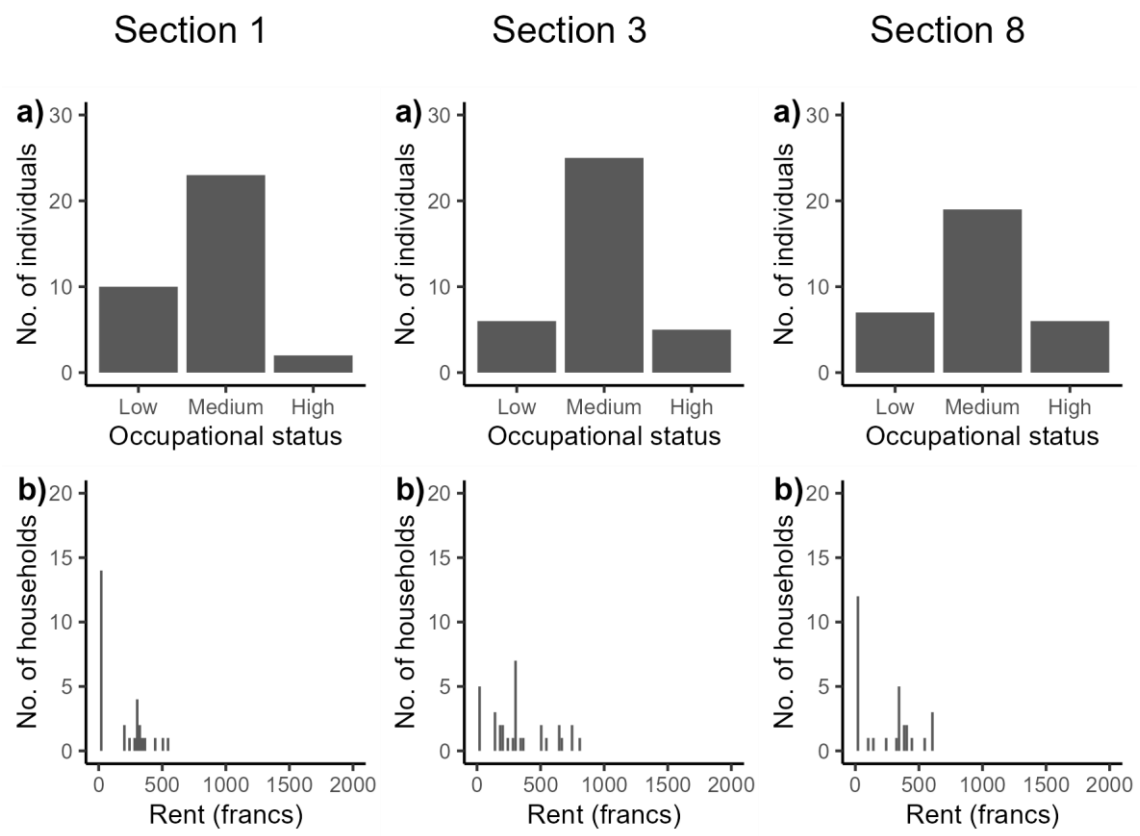


Figure 5-13. *Sections* 1, 3 and 8, occupational status and rent
These *sections* have households in all occupational status groups. Plots show a) the occupational status of the breadwinners and b) the annual rent.

5.6 Statistical analysis of factors related to age at death

5.6.1 Statistical model

The question I am considering here is: what are the effects of socioeconomic conditions on age at death for the sample I am studying, that is married men who died in Nancy between the ages of 26 and 49. I am, therefore, focussing on a very specific sample, as this is what I am able to do with the available data. The age at which the breadwinner died might reasonably be expected to be related to other variables such as rent (e.g. indicative of income) and persons per room (representing overcrowding which might, for example, lead to higher risk of infectious diseases), as well as other characteristics such as the area of the city in which they reside.

To examine possible relationships between age at death and other variables, a correlation matrix was produced; see Appendix 8.4.3, Figure 8-10. None of the variables appear to have a strong correlation with age at death, but to test this

formally, a number of regressions were run based on the linear specification shown in [6]. The age at death of the head of household is denoted by y_{ihs}, and the full statistical model is given by

$$y_{ihs} = \beta_1 + \beta_2 \boldsymbol{X}_i + \gamma \boldsymbol{Z}_h + \eta_s + u_i \qquad [6]$$

for individuals $i = 1, \ldots, N$ in household *h* = 1,…,*N*, in *section* 1,…,*M*. In this specification, $\boldsymbol{X}_i$ denotes variables relating to the individual, including occupational status and season of death; $\mathbf{Z}_{\boldsymbol{h}}$ denotes variables relating to the household such as rent, persons per room and the number of children living in the household; and η_s are dummies for the eight *sections* of Nancy; the constant term β_1 captures common factors; and u_i is an error term. The socioeconomic variables I am most interested in are occupation, rent and number of rooms. To account for potential heteroskedasticity, I use robust standard errors throughout the analysis and I allow for the error term to be correlated within geographical areas by calculating standard errors that are clustered at the level of the *section*. As a robustness check, an alternative analysis is run with robust standard errors without clustering, allowing for heteroskedasticity of unknown origin. Additional checks are also undertaken to test for collinearity of the independent variables.

Occupational status is included in the model to test the findings in the literature which suggest that higher occupational status has a positive impact on mortality. The three categories, high, medium and low, are included; two versions of this variable are used, one with high occupational status as the reference category and one with low status as the reference category, to test the statistical significance of the different comparisons. Persons per room is included as it represents living conditions with higher persons per room indicating a higher level of overcrowding, which has been strongly associated in other studies with higher infant and early childhood mortality. Its inclusion here tests whether there is also an association with adult mortality. Rent is included as a proxy for income, to test previous findings that higher income individuals have lower mortality.

Additional variables were included which were not related to socioeconomic conditions, but might nevertheless impact on age at death. The number of children living at home is included as the correlation matrix (Figure 8-10) indicated an association with the age of death of the father. Logically, this measure could have two opposing influences: a large number of children might, other things equal, indicate sufficient income to support them (positive influence), which seems to have been the case in France at this time (Labor, 1891), or could lead to more overcrowding and an increased likelihood of infectious disease (negative influence). I have shown that deaths followed a seasonal pattern, and this variable is included to test if it had an association with age at death. Finally, knowing that there were differences between the eight *sections* of Nancy, a dummy variable was included to see if there were area effects associated with age at death. As discussed in 5.5.2, *Section* 2 has been chosen as the reference category, as it was one of the two *sections* of high socioeconomic status according to a number of measures (the other option was *Section* 6).

The first set of regressions uses the high/medium/low categories to indicate occupational status. A second set of regressions was also run, replacing this occupational status dummy with a binary variable looking at whether the breadwinner was engaged in manual or non-manual work. It seems intuitive that manual work, which would involve physical effort and may involve some danger, for example in the building trades, could lead to a higher risk of dying at a younger age. This has been suggested to be the case in some of the literature discussed earlier (e.g. Woods, 2000).

5.6.2 Results

Various regressions were run for different specifications of [6] and the results are shown in Table 5-4. The first specification, Model 1, includes merely the occupational status dummies, comparing medium and low occupational status against the reference category, high status. Model 2 includes only the two additional socioeconomic measures specific to the household: persons per room and domestic rent. Model 3 repeats Model 1 but includes the number of children living in the household. Model 4 includes both occupational status and the other

socioeconomic variables, plus the number of children. Model 5 repeats Model 4 but also includes dummies for the season of death and for the section where the household lived. Model 6 repeats Model 5 but uses low occupational status as the reference category instead of high occupational status.

In Table 5-4, the analysis shows that occupational status is consistently related to age at death, with low and medium occupational status being associated with death at a lower age than for high status individuals. High occupational status individuals are likely to die at an older age than low status individuals, but medium status individuals do not have a statistically significant difference in age at death relative to low status individuals. A higher level of rent is associated with death at an older age, but only in Model 2 and only at the 5% significance level. This is surprising in view of the relatively high Gini coefficient seen in the Nancy sample, which would lead us to expect that rent (proxying income) would be an important explanatory factor for age of death.

Persons per room has no statistically significant association with age at death, suggesting that any risks associated with overcrowding were not significant for adult mortality, although we know from other studies that they were strongly associated with childhood mortality. The number of children living in the household is associated with a higher age at death for the breadwinner in all models where it is included, but the statistical significance falls to 5% when *section* dummies are included. This suggests that having a higher number of children may confer some mortality advantage on the breadwinner; this may indicate that the number of children acts as a proxy for socioeconomic status, although there is no evidence of collinearity between the variables, as discussed below. The season of death had no association with age at death, but *Sections* 3, 4, 6, 7 and 8 were all associated with a death at a younger age than the reference category, *Section* 2.

Table 5-4. Socioeconomic conditions and the age at death, Nancy, 1895-97

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	42.937***	38.907***	42.051***	41.605***	43.084***	39.661***
	(0.732)	(0.890)	(0.650)	(1.056)	(0.861)	(1.300)
Low occupational status	-3.696***		-4.210***	-3.558***	-3.422**	
	(0.735)		(0.826)	(0.850)	(1.021)	
Medium occupational status	-3.015***		-3.357***	-2.976***	-2.593***	0.829
	(0.718)		(0.713)	(0.619)	(0.580)	(0.697)
High occupational status						3.422**
						(1.021)
Rent		0.002*		0.001	0.002	0.002
		(0.001)		(0.001)	(0.002)	(0.002)
Persons per room		0.204		-0.155	-0.051	-0.051
		(0.244)		(0.315)	(0.308)	(0.308)
Number of children			0.645***	0.727**	0.693*	0.693*
			(0.177)	(0.262)	(0.291)	(0.291)
Spring-Summer					-0.548	-0.548
					(0.990)	(0.990)
Section 1					-0.833	-0.833
					(0.539)	(0.539)
Section 3					-3.085***	-3.085***
					(0.383)	(0.383)
Section 4					-3.379***	-3.379***
					(0.371)	(0.371)
Section 5					-0.464	-0.464
					(0.395)	(0.395)
Section 6					-3.129***	-3.129***
					(0.182)	(0.182)
Section 7					-5.425***	-5.425***
					(0.695)	(0.695)
Section 8					-1.201*	-1.201*
					(0.483)	(0.483)
R^2	0.029	0.016	0.072	0.078	0.132	0.132
Number of observations	161	161	161	161	161	161

Notes: Estimates shown for the specification in equation [6]. Mean of age at death = 40.1 years. Least squares estimate with robust standard errors clustered on section. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

My main conclusion from Table 5-4 is that occupational status has an effect on age at death over and above that which is associated with other variables included in the various models. Geographical location is also strongly statistically significant for a number of areas, suggesting that area effects are acting in addition to the impact of, for example, income or occupation. The R^2 value for all models is low, showing that they only explain a small proportion of variation in the age at death of the breadwinner.

An additional series of regressions was run replacing the occupational status dummies with a binary dummy for manual or non-manual work. To avoid

duplication, only Models 1, 3, 4 and 5 have been re-run and the results of these regressions are shown in Table 5-5. Undertaking manual work is associated with dying at a younger age in all models. The influence of having children living at home, or of living in the various sections of the city is similar to that seen in Table 5-4, and rent, persons per room and season of death have no association with age at death. The impact of manual work is in addition to any influence of income, overcrowding, number of children or location of dwelling, which are all accounted for in Model 5.

Table 5-5. Manual occupations and the age at death, Nancy, 1895-97

	Model 1	Model 3	Model 4	Model 5
(Intercept)	41.274***	40.241***	40.251***	41.854***
	(0.396)	(0.552)	(0.798)	(0.794)
Manual occupations	-1.911***	-2.337***	-2.120***	-1.891**
	(0.531)	(0.552)	(0.588)	(0.665)
Number of children		0.681***	0.737**	0.692*
		(0.167)	(0.261)	(0.284)
Rent			0.000	0.002
			(0.001)	(0.001)
Persons per room			-0.122	-0.001
			(0.320)	(0.301)
Spring-Summer				-0.713
				(0.850)
Section 1				-0.944*
				(0.370)
Section 3				-2.810***
				(0.312)
Section 4				-3.398***
				(0.288)
Section 5				-0.692*
				(0.341)
Section 6				-3.249***
				(0.184)
Section 7				-5.721***
				(0.483)
Section 8				-1.110**
				(0.361)
R^2	0.026	0.074	0.075	0.128
Number of observations	161	161	161	161

Notes: Estimates shown for the specification in equation [6]. Compares manual occupations against non-manual ones. Mean of age at death = 40.1 years. Least squares estimate with robust standard errors clustered on section. Number of observations: 161 households; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Once again, the R^2 values in Table 5-5 are low, showing that the models only explain a small proportion of variation in the age at death of the breadwinner.

I undertook a number of robustness tests, which further support the main results analysed above. The regressions in Table 5-4 and Table 5-5 were repeated using only robust standard errors, allowing for heteroskadasticity of unknown origin. This output confirms that the main findings, that low and medium occupational status or having a manual occupation is associated with dying at a younger age, are robust. However, the precision with which the standard errors are estimated is naturally reduced; see Appendix 8.4.4, Table 8-11 and Table 8-12.

In addition, the occupational status regressions shown in Table 5-4 were run using the slightly larger sample of 164 households, including the three records which were outliers where the rent and occupation were at odds with each other. This made no change to the statistical significance of occupational status. These results are shown in Appendix 8.4.4, Table 8-13.

To test for collinearity between the independent variables, variance inflation factors (VIF) were calculated, and no evidence was found of any issues, with all VIFs being below 2 (Appendix 8.4.4, Figure 8-11).

All of the above models have a very low R^2 value, indicating that they explain only a small amount of the variation in the age at death. To understand whether this was simply a function of the selected explanatory variables, I tested the model fit including additional available variables: number of rooms, total size of household and self-employed or employee. Even when I added these variables to the regression, the R^2 value did not increase above 0.15. This suggests that, although occupational status and geographical location both have an association with age at death of a breadwinner, most the of variation is random or unknown.

5.7 Discussion: Influences on age at death

Previous work on the influence of various characteristics on the risk of death have focussed predominantly on infant and early childhood mortality. Work that has been undertaken on adults has focussed on occupational status, with those employed in a higher status occupation having a higher life expectancy than those in lower status occupations. This work was unable to separate out exactly what it was about occupation that created this association, although it is implied that it may be due to access to a higher income, as is suggested by the

fundamental cause theory (Phelan et al., 2004). It has also been proposed that differing life expectancies between occupations of similar status was associated with more or less dangerous work environments (Woods, 2000).

My results show that, for my sample of men, the occupational status of the individual is associated with the age of death, over and above living conditions, income and any seasonal or location effects. The association between age at death and occupational status is as expected, with individuals in lower and medium status occupations dying at a younger age than those in high status occupations. Rent, as a proxy for income, is included to test whether the association between status and age at death is due to income differentials. Although there is a positive association between age at death and a higher income, when occupational status is also included in the model the statistical significance of income disappears, suggesting it was not the rich who died older, but those who worked in higher status occupations. This indicates that income and occupation should be viewed separately in historical studies, and not treated as proxies for one another. The association between lower occupational status and lower age at death remains when the influences of rent, persons per room, number of children, season of death and *section* of residence are partialled out.

Living in *Sections* 3, 4, 6, 7 and 8 of Nancy is associated with dying at a lower age than living in the reference category, *Section* 2. *Sections* 3, 4 and 7 were poorer areas, as discussed in 5.5.2, but *Section* 6 was one of the wealthier areas. In any case, status, rent and persons per room are already included in the model, so it is not immediately clear why there should be additional area impacts. One could speculate that there were events (e.g. local disease outbreaks) or structural differences (e.g. building developments being undertaken in some areas but not others) that created these differences. The quality of the external environment may also have varied with regard to, for example, access to open space and the presence of air pollution, although I do not currently have sufficient information to state whether this was the case. Nevertheless, the key finding that occupational status is associated with age at death remains clear even when area effects are included in the model.

It seems that there is something about occupational status that acts over and above income and the influences of the home environment and the local area, which are captured in other variables in my models. We can speculate that the type of work undertaken (non-manual) or the environment in which the work takes place (not within a factory or workshop) might bestow an added advantage on the individual over and above what access to additional resources are assumed to create. This speculation is supported by Woods' suggestion that occupation may impact on the life chances of individuals because 'the type of work in which an adult was engaged could injure his or her health through crowding together in an insanitary environment, through contact with poisonous substances, through exposure to situations with a high accident risk, or through contact with the already ill' (Woods, 2000, p239). Although occupation has been used in other research as a proxy for income, my research suggests that when considering deaths of adult breadwinners, occupational status should be viewed separately from income.

The models discussed in this chapter only explain a small proportion of the variation in age at death of the breadwinner. Although high occupational status does confer some advantage for living longer, within this age group that advantage is relatively small. This is in contrast to the known advantage of higher socioeconomic status on the likelihood of death at young ages, where death rates were half those of the poorest areas, as was discussed in Section 5.2. It would appear that once a man has married and reached the age of 26, thus having survived the very high risk of death in early childhood, the majority of the variation in age of death is unexplained or random with respect to socioeconomic conditions.

Chapter 6 The effect of the death of the breadwinner on the remaining family: evidence from a household panel dataset from Nancy, France from 1895

6.1 Introduction

In this chapter I consider how the financial situation of the family changed following the loss of the breadwinner during the late 19th century in Nancy, France, and which socioeconomic conditions, if any, helped or harmed their ability to cope. In Chapter 5, I was able to show that the age at which the men in my sample died was associated with socioeconomic conditions, with occupational status playing a distinct role. I now consider the impact of the bereavement on the families left behind. The role of socioeconomic conditions is considered, alongside the possible impact of geographical location, which may have an influence in its own right, or act as a channel for socioeconomic influences. I also briefly consider the impact of the loss of the breadwinner on other aspects of the family's life: family mortality, the widow's involvement in paid work, the remarriage of widows, and migration away from the city.

There is a relatively small literature that has investigated the impact of the death of the breadwinner on the remaining family in the nineteenth century, but what literature there is suggests this impact would be negative. Analysis of family incomes in France around the beginning of the twentieth century suggests that the breadwinner contributed over 70% of total earnings (U.S. Department of Commerce and Labour, 1909), so any loss would be a major financial blow. Although this is high, the proportional contribution of male heads of household was actually lower in France than in other countries where data was collected at the time, for example in the UK or Germany (Gazeley et al., 2023). The loss of the father has been associated with higher child mortality than in two-parent families, with the risk of death being particularly high soon after the bereavement (Beekink et al., 2002, Derosas, 2002). Some studies have also shown higher mortality for widows (Beekink et al., 2002) but others found no

difference in mortality between widows and married women (Derosas, 2002). Paternal loss in childhood is also associated with an increased risk of mortality throughout the child's life (Debiasi et al., 2021), with lower adult occupational status (Rosenbaum-Feldbrügge, 2019) and with an increased risk of the family disappearing as a recognisable unit (Wall, 2002).

Lower socioeconomic conditions have been shown to worsen the impact of the loss of the father. For example, in Belgium and in Venice in the late 1800s, the highest subsequent mortality was observed in low socioeconomic condition families (Beekink et al., 2002, Derosas, 2002). In Devon, also in the late 1800s, the likelihood of the family unit being dissolved increased for lower occupation families and reduced for the better off, particularly for the families of tradesmen (Wall, 2002). However, in terms of the long-term mortality effects of parental loss in Sweden in the late 1800s and early 1900s, socioeconomic conditions did not appear to play a role (Debiasi et al., 2021). Area differentials in the way bereaved families coped have also been noted; most work has focussed on differences between rural and urban settings (e.g. Alter et al., 2002, Farron and Renard, 2002) but differentials within urban areas have also been noted (Derosas, 2002).

As discussed in Chapter 5, the Nancy dataset that I have created uses the death of the male head of household as the focal point for creating a record. Once the death of the breadwinner had been recorded, details about the current and subsequent family circumstances were transcribed, including rent paid, type and size of property and number of children. The occupation of the deceased husband, and later the widow, was also noted, as were subsequent family mortality, remarriage of the widow or migration away from Nancy. Changes in the families' circumstances were followed for up to three years, a process that was only possible due to the detailed annual Nancy censuses. Sample attrition occurs over the period during which data were collected, with the largest subsequent sample being in the year following the death of the head of household. Most of my analysis focusses on this year.

Using the panel dataset, I compare the families' financial position at the time of bereavement to that in subsequent years. Two smaller samples were also

collected: one of the deceased families in the year prior to the death and the other of control families where the breadwinner did not die. These permitted further comparative analysis with the year prior to death and with families where the head of household did not die. Statistical analysis using a linear regression model was also undertaken to examine the association between socioeconomic conditions and changes in the finances of the deceased's families.

My analysis of the Nancy dataset indicates that the accommodation position of the families following the breadwinner's death was less stable than it had been up to that point, and less stable than for a group of control families who had not suffered bereavement. Average rent paid by bereaved families fell in the years following the breadwinner's death, although the position appears to have stabilised somewhat after around three years. This average fall in rent, at around 10%, is not as marked as might be expected from the loss of over 70% of family income. Specific measures of socioeconomic conditions at the household level were not associated with accommodation changes in the manner suggested by the current literature: persons per room and high and low occupational status (of the deceased breadwinner) had no statistically significant association with changes in rent. Medium occupational status may be associated with paying an increased rent as compared with those of high occupational status. Area effects on accommodation choices were seen, however, with families living in the 'better' areas of the city appearing to cope better financially following bereavement. This may indicate that socioeconomic conditions are working through geographic channels, although the mechanism for this is unclear.

The loss of the breadwinner also had impacts on other aspects of the lives of the families in the Nancy sample. Although the number of subsequent deaths of family members is small, it appears that the families of medium or low occupational status breadwinners experienced higher levels of mortality than those of higher status breadwinners. Far more widows took up paid employment than had worked when the husband was alive. Around a quarter of widows remarried within 10 years, with widows having no or very few children appearing more likely to remarry than those with large families. Migration away from the city appeared to be more common in higher status families than in others,

although the numbers involved were small. These findings are generally in line with current literature.

In summary, the creation of a dataset which follows the families of deceased heads of household over the subsequent three years allows an insight into how the life of the family changed in this period immediately post-bereavement. These records, drawn from annual censuses, are close enough to each other to minimise the loss of key information (see e.g. Derosas and Saito, 2002), which is often a problem with quinquennial and decennial censuses. My findings suggest that although the impact of the loss of the breadwinner was disruptive, especially in the first year, the change in rents paid was far smaller than the known contribution of breadwinners to family finances might lead one to expect. Socioeconomic factors appear to have less influence than has been found in other studies, although these may work, to some extent, via area effects. My research provides evidence on how families reacted to a severe financial shock in a period where social insurance to deal with such shocks was very limited.

The remainder of this chapter is set out as follows. Section 6.2 is a review of literature that has looked at the impact of the death of the male head of household. Section 6.3 gives the historical context for the Nancy data and describes the Nancy dataset used in this chapter. Section 6.4 analyses the changes in accommodation expenditure following the death or the breadwinner and compares these with the year prior to his death and with a control sample. Section 6.5 undertakes statistical analysis of the factors associated with the change in rent following the death of the breadwinner. Section 6.6 briefly considers the impact of the death on other aspects of the family's life such as mortality and remarriage. Section 6.7 discusses the findings of this chapter.

6.2 Literature review: the impact of the death of the head of household

A review of the literature on paternal loss in the nineteenth century suggests the death of the breadwinner had a major negative impact on the family left behind. This impact was found in terms of subsequent family mortality in both the short and long-term, as well as on the adult occupational status of children

who suffered paternal loss. The role of socioeconomic conditions in determining the severity of the impact suggests that, on the whole, lower socioeconomic condition families fared worse, although this was not always the case. There were also area differentials between how families coped, with those in rural areas having a slight advantage over urban areas in terms of family stability and the mortality of widows. Within an urban area, the mortality differentials between different areas have been associated with cultural and environmental differences, over and above the impact of socioeconomic conditions.

When examining the impact of the loss of either parent, a difference has been found between the loss of the father and the loss of the mother, with the loss of the mother having the more severe consequences for the children (e.g. Horrell and Oxley, 2013, Humphries, 2010, Jaadla and Lust, 2021, Reher and Gonzalez-Quinones, 2003). More specifically, a study in the Netherlands, 1850-1952, showed that the loss of the father was associated with reduced economic resources while that of the mother was associated with a loss of care. This study found that the adult occupational status of children suffering paternal loss was lower than that of children with two parents, but higher than for those suffering maternal loss (Rosenbaum-Feldbrügge, 2019).

The mortality risk to children following the death of the male breadwinner has been shown to increase. In the town of Woerden in the Netherlands from 1850-1930, the risk of death for children rose fivefold in the immediate aftermath of the father's death (Beekink et al., 2002). This study looked at 1,245 families, around 50 of which suffered paternal bereavement. Interestingly, the negative impact of the loss of the father did not have a longer-term impact on child mortality, although the loss of the mother did (Beekink et al., 2002).

An analysis of families in mid-nineteenth century Venice who suffered the death of the father also considered what impact this had on subsequent family deaths. This study had a sample size of 250 fatherless families and showed an increased mortality risk for children in fatherless families, but found the risk of death for the widow was no different from that for married women (Derosas, 2002). On the other hand, Farron and Renard, looking at the deaths of around 1300 men in nineteenth-century Milan, found an increased risk of mortality for both children

and widows following the breadwinner's death (Farron and Renard, 2002). A large study in Sweden researched the impact of parental loss in childhood on mortality in adulthood and found the impact of paternal loss to be far-reaching. Children who lost a father suffered an increased risk of mortality throughout their lives as compared with children who had two parents (Debiasi et al., 2021).

An alternative approach to the impact of the loss of the father has been to investigate whether the family survived in a recognisable form thereafter. Survival was defined as the family appearing in the next census in the same town, headed either by the widow or another member who was part of the original family. This study looked at Colyton, Devon in the second half of the nineteenth century and drew on data from death certificates and the decennial censuses from 1841-1891. It included 345 households who had experienced the death of the father: less than half of households survived to the next census (Wall, 2002). However, only 34 of the fathers were under the age of 45, and one might expect that for younger families, the impact of the loss might be larger.

It would seem reasonable to assume that families of higher socioeconomic status would be able to survive the impact of the loss of the father more easily. Beekink et al found increased mortality for children of unskilled manual workers compared to other occupational groups (Beekink et al., 2002). Derosas showed the mortality risk to infants and children under ten to be much higher where the deceased father had been a day labourer as against higher status occupations, with the death of the father magnifying the effect of socioeconomic differentials seen in two-parent families (Derosas, 2002). Studying mortality in Scandinavian countries from the early eighteenth century to the late nineteenth century, Bengtsson found evidence of consumption smoothing[27] over the lifetime of a family, which could help a family survive times of stress. However, the ability to undertake such smoothing varied by social class, as those on the very lowest rung of society had little opportunity for saving so were most at risk in difficult times, such as the loss of the breadwinner (Bengtsson, 2002).

[27] Consumption smoothing refers to a tendency seen in individuals and families to borrow or save at various periods of life in order to permit relatively equal consumption over a lifetime, even though income may vary.

Wall specifically studied the impact of occupation on the likelihood of the family surviving, as defined above, and found that the proportion of families surviving was highest for tradesmen (63%); it was lowest for labourers (43%) and those whose occupation was listed as miscellaneous (36%). The families of gentlemen and professionals, which have the highest occupational status, did not fair particularly well, with only 50% of families surviving, but 21% of this group migrated out of the area, which may have been an option open to the better off more than to other classes (Wall, 2002).

As the loss of the father was primarily a financial blow to the family, access to resources replacing this loss would need to be found. Various charitable and other support was available to widows, but this was unlikely fully to compensate for the loss of income, as usually only outdoor relief[28] was provided, especially for younger widows, which did not cover accommodation expenses (Van Poppel, 1995). Nevertheless, widows were generally counted among the 'worthy' poor and therefore might have access to charity and other assistance that wouldn't have been available when there was a male breadwinner (Blom, 1991). An alternative option for widows was to go out to work, but the sort of work women could easily obtain such as washing, cleaning and sewing was unreliable and is considered unlikely to replace the loss of the man's income (Blom, 1991). Family support for a widow was likely to be important, but, as the families of poor widows were often poor themselves, they were less likely to be in a position to provide assistance (Blom, 1991), again confirming the importance of socioeconomic factors. There is some indication that widows were more likely to resort to criminality, with widows in France in the eighteenth century being the only female group to appear in crime statistics at the same level as they were represented in the population as a whole (Castan, 1980, Hufton, 1984).

Family ownership of a business has been found to be beneficial in coping with the death of the head of household. Hufton states that the situation '[b]est tailored to cope with the eventuality of the husband's death was the family economy that pivoted upon the small business, especially the café-bar… tavern,

[28] Outdoor relief refers to financial or non-monetary support given to people living in the community, as opposed to housing these people in institutions such as a workhouse, orphanage, etc.

lodging houses [and] victualer's shop' (Hufton, 1984, p364). Other research supports this, confirming that the families most likely to continue in a recognisable form were those of tradesmen (Wall, 2002).

Not all studies show a clear impact of socioeconomic conditions following the death of the breadwinner. Debiasi et al found the increased risk of mortality for those who lost a father during childhood lasted throughout their lives, but found no difference between socioeconomic classes, suggesting that at least in terms of the long-term mortality effects of paternal loss, socioeconomic conditions did not play a role (Debiasi et al., 2021).

The impact of place has been shown to be important on family outcomes following the death of the breadwinner. Studies focussing on the nineteenth century compared: Vernon, a rural area of France, with Milan, an Italian city (Farron and Renard, 2002); a rural versus an urban setting in Belgium (Alter et al., 2002); and three sub-districts of Venice (Derosas, 2002). Farron and Renard found no difference in the mortality risk for children of a deceased breadwinner in the two areas he studied, but showed there was an increased mortality risk for widows in urban Milan as opposed to rural Vernon. In the study focussing on Belgium, households in rural areas generally experienced less out-migration and a higher level of stability following bereavement, with no clear difference in mortality between rural and urban areas. Different areas of Venice did experience significant differentials in mortality following paternal loss, which Derosas ascribes to ethnicity differences, with children in Jewish families having far lower mortality rates than those in Catholic families, from whom they lived geographically separated.

In summary, research has shown that the loss of the main breadwinner in the nineteenth century resulted in higher subsequent family mortality in both the short and long-term, as well as lower adult occupational status of children who suffered paternal loss. The role of socioeconomic conditions in determining the severity of the impact suggests that, on the whole, families with lower socioeconomic conditions fared worse, although this was not always the case. There were also area differentials between how families coped, over and above the impact of socioeconomic conditions, with families in rural areas tending to

manage better than those in urban areas, and environmental and cultural influences impacting on differences within urban areas.

Research on the immediate aftermath of the breadwinner's death has focused predominantly on events that can be easily and reliably measured, such as the subsequent death of the wife or children. When financial circumstances have been included in studies, these have tended to be framed in terms of the occupation of the father at the time of his death (e.g. Beekink et al., 2002, Derosas, 2002). There is little published work on the impact of the death of a breadwinner on the family finances in the years immediately following that death, although one study does consider the long-term impact by examining the adult occupational status of the children (Rosenbaum-Feldbrügge, 2019). The implication is that the immediate financial impact of the loss of the breadwinner would be significant and negative, with reduced family income being a likely cause of increased childhood deaths (Beekink et al., 2002). None of the papers examined included the family's financial status following the loss of the father as the independent variable of study. Because of the detailed nature of the annual censuses undertaken in Nancy, I am able to examine this time period in detail for my sample of families, looking at changes in rents paid following the loss of the father. I can also analyse whether the impact of the breadwinner's death varied by socioeconomic status or geographical area.

6.3 Bereaved families in Nancy

6.3.1 Family finances in late nineteenth century Nancy

In the 1890s, Nancy was the main administrative centre in north-east France. It had undergone a period of rapid growth and industrialisation following the Franco-Prussian war of 1870. In 1896 its population was around 84,000, an increase of around 60% on pre-war levels. Geographically, Nancy consisted of eight *sections*, four of which covered the older central area with the remaining four being much larger *sections* which spread outwards to the north, south, east and west. A map of the *sections* and further details are provided in Chapter 5, Section 5.3, Figure 5-1.

The loss of the breadwinner, as the male head of a household probably was in the late nineteenth century, is likely to have had a profound impact on family finances. Average incomes for working class men in Nancy in 1896 ranged from 16f (francs) per week for labourers to 26f per week for a printer (Insee, 1966). This would equate to 840f per year for a labourer, assuming the individual was fully employed all year, which is unlikely given that, by definition, day workers had no guarantee of employment. The annual wage for a printer would be around 1,352f per year[29]. Women and children earned considerably less, both because their working hours and occupations were limited by law, and because their rate of pay was roughly half that of men (Bourdieu and Reynaud, 2006, Insee, 1966). In examples of how French household incomes were made up in 1905, provided by the US Bureau of Labor, the average weekly wage of the husband was 34f, that of the wife was 5.5f and the average contribution by children was 7.9f. The breadwinner therefore contributed, on average, 72% of the household income (U.S. Department of Commerce and Labour, 1909, p74).

In late nineteenth century Nancy, only those households that had an independent income or ran their own businesses had some control over their own finances. Most workers in skilled occupations, such as shoemakers and file cutters, had no business to hand over. They did not even have a guarantee of long-term employment as factories and workshops recruited workers and then laid them off dependent on demand and the state of the business cycle (Boquillon et al., 2008), meaning their ability to save would have been compromised. It is likely that most of the Nancy families found themselves in a precarious position once the income provided by the deceased husband was lost. Those in the worst position were probably the families of day workers or similar, who had had no guarantee of work from day to day. They were very unlikely to have been able to build up any savings.

There was no systematic provision of welfare by the state in France in the late nineteenth century, with a legal requirement for communes to assist the poor only introduced in 1905 (Weiss, 1983) and a voluntary national insurance scheme

[29] The assumption has been made that the average working week was 60 hours, which may be an underestimate, as the working day was only limited to 10 hours in 1900 so may have exceed this in the 1890s (Bourdieu and Renauld, 2006).

in 1910 (Nord, 1994). However, charitable institutions and mutual associations are known to have existed in Nancy, as they did elsewhere in France, as well as a *bureau de bienfaisance* (charity office) administered by the city authorities (Price, 1983, Sicard-Lenattier, 2002). Some institutions, such as the St Stanislas Orphanage (*L'Hospice des orphelins sous l'invocation à Sant-Stanislas*), are mentioned in the censuses. It seems likely, therefore, that some level of support was available to widows, but that this would not have replaced the income of the deceased breadwinner.

6.3.2 Household panel data for the Nancy sample

The main Nancy dataset is based on a sample of 161 married men who died between July 1895 and March 1897 and lived in Nancy at the time of their death. It was possible to create this detailed dataset because of the practice in Nancy of, unusually, undertaking a full census (*recensement*) every year (national censuses were legally required only every five years). Nancy's annual censuses provided information on the deceased men, their ages and occupations, their families and their accommodation, including rent paid. Data were also collected for the widow and children left behind, for all years in which they could be found in the censuses from 1895 to 1898. The size of the sample is not dissimilar to those in many other studies: the number of dead fathers in the Woerden study was 50 (Beekink et al., 2002), in the Venice study was 250 (Derosas, 2002) and in the Devon study was 345 (Wall, 2002), but only 34 of these were under the age of 45, i.e. similar to my working-age population.

Full details of how the data were collected and which variables were and were not available is covered in Chapter 5, where analysis focussed on the year in which the breadwinner died. The current chapter concentrates on what happened to the family in subsequent years. It is recognised that, when tracing families forward via censuses, there will inevitably be sample attrition, with individuals or households lost due to out-migration or other changes (Wall, 2002). An advantage of the annual censuses in Nancy, relative to most national censuses that take place every 5 or 10 years, is that they are close enough in time to minimise this risk of lost records. Sample attrition is additionally

mitigated by the practice in the Nancy censuses of marking where a household moved to, if known.

Some families were, nevertheless, lost to the sample each year. This might be because they moved away from Nancy, in which case the destination town was often indicated in the census, or because no onward address was provided to the record takers. In the latter case records were sometimes marked *psd* or *parti sans domicile* (left without address). A search was made for the missing widows using the genealogy website *Filae* (Filae, 2023), which provides on-line links to other civil documents, and any information found was added to the dataset. Filae was also searched systematically to identify if the widows remarried[30] or died after 1898, and records were updated to include this information.

Annual censuses permit the systemic examination of the immediate impact of the bereavement, which other censuses do not. Data variables collected for the years following the breadwinner's death were the same as those collected for the year of death (details in Chapter 5), but particular attention was now focussed on changes to the household accommodation. Some households moved to cheaper or more expensive accommodation. Some stayed in the same accommodation but still experienced a change in rent. Rent is used as a proxy for income and provides an indication of how the household's finances were performing. Data relating to the changing family structure were also recorded. Particular effort was made to record any deaths of family members or the remarriage of the widow.

The occupations of the breadwinner and other family members were transcribed from the censuses and then coded according to the HISCLASS system of occupational classification (Van Leeuwen and Maas, 2011). Details of how this was undertaken for male breadwinners are covered in Chapter 5, and the same process was used when categorising the occupations of widows. The system contains twelve categories, which I further grouped into only three types of

[30] These searches were necessarily dependent on the consistent spelling of names, so some records may have been missed.

occupations: high (categories 1-2), medium (categories 3-8) and low (categories 9-12).

In addition to the main dataset, I created two extensions. Firstly, data were collected for the year prior to the death of the head of household. This provided the opportunity to analyse any changes in accommodation and/or rent in the period before the death occurred and compare these with the subsequent years. It is not possible to say if an earlier move was completely unconnected with the death of the breadwinner, as a long illness preceding death may create a deterioration in financial circumstances before the death itself. Other researchers have noted that a family's living arrangements sometimes changed in advance of the death of the head of household, because the death was expected (Wall, 2002). As no information is available on cause of death (see discussion in Chapter 5), I cannot identify whether a death was likely to have been anticipated. Bearing in mind this caveat, it was useful to compare data from the period prior to the breadwinner's death with subsequent accommodation changes.

Secondly, within the constraints of the data collection process, I was also able to collect data for 52 control families, i.e. families living in Nancy 1895-1898, where the breadwinner did not die. As far as possible, the same variables were collected for this group as for the main sample, enabling me to make comparisons between the two sets of data. The method used for selecting controls is shown in the appendices, 8.5.1.

6.3.3 Overview of the data in the main sample

The majority of families in Nancy lived in rented accommodation both before and after the death of the main breadwinner. There were two exceptions to this: the family may be the *propriétaire,* owning the building in which they lived and often renting out part of it to other families (eight households); or the family could live in a wooden shack, sometimes called a *baraque,* which they built themselves and did not have to pay rent on, although they probably paid ground rent (six households). The poorest tenants were probably those who lived in *garnis,* furnished accommodation similar to a lodging house in a UK city,

where rooms or beds were let for short periods. Due to their itinerant nature, inhabitants of *garnis* are the most difficult to trace in the censuses. They are often marked as 'left without address' or there is simply no indication of the place they moved to, despite their name(s) being crossed out. The spread of accommodation types in my sample, as at the date of the breadwinner's death, is shown in Figure 6-1a), and the number of rooms, excluding *garni* where the number of rooms was unknown, is shown in Figure 6-1b). The majority of families lived in apartments of 1 or 2 rooms.

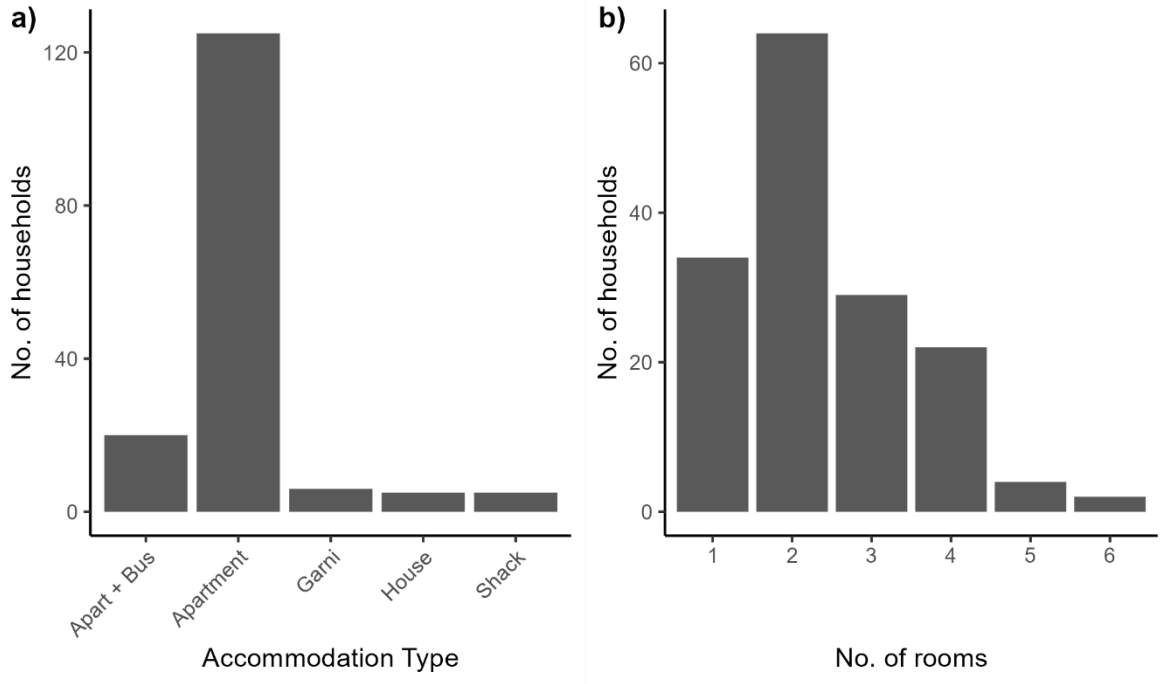


Figure 6-1. Accommodation occupied by households at the time of husband's death
Plots show a) accommodation type for all 161 households and b) number of rooms per dwelling for 155 households, excluding *garnis*.

In the year of death, recorded rents varied from 2f to 1,800f per year. Rents for *garnis*, which are never provided, are imputed at 1f. It would be expected that a higher rent would provide larger accommodation, in terms of the number of rooms, but this relationship only existed loosely, as the correlation between the two measures is 0.57: a higher rent was generally, but not always, associated with more rooms. Apartments of one room always paid less than 500f in rent, but some low rents (under 300f) also managed to secure accommodation of three, four or, in one case, five rooms.

The differences between the eight *sections* of Nancy are discussed in detail in Chapter 5, but in summary *Section* 2 and 6 were the better off areas, with the highest average rents and no breadwinners with low occupational status. *Sections* 4, 5 and 7 were the worse off areas, with lower average rents and no breadwinners with high occupational status. At the time of the husband's death there were poor families from my sample (paying less than 100f, a very low rent[31]) in all eight *sections* of the city, but richer families (paying over 1000f[32]) were only found in *Sections* 2, 4, 6 and 7.

In the year of the husband's death, the ages of the wives ranged from 18 to 61 with an average age of between 36 and 37 years (Figure 6-2). I lack age data for four of the wives, so this information is based on 157 records. It is interesting to note that although the oldest husband in the sample of deceased was 49, a number of wives were over 50 and one was over 60.

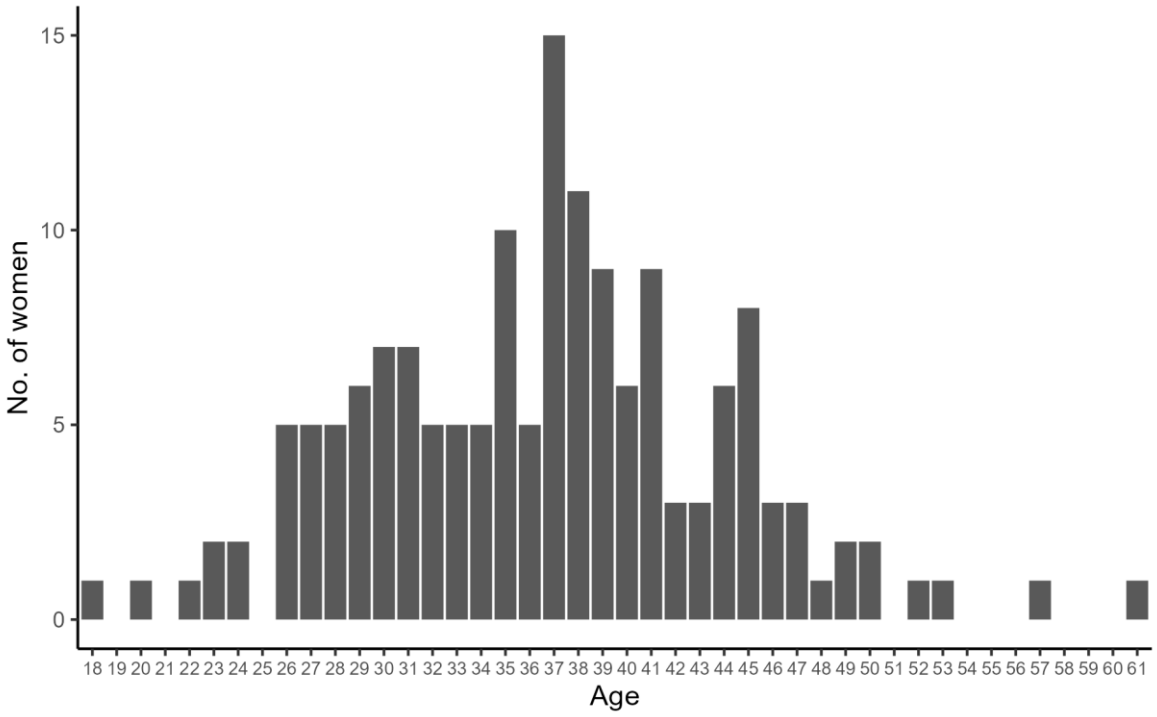


Figure 6-2. Ages of the wives at the time of the death of the husband

Only twelve of the wives are shown as having an occupation before the death of the husband. Of these women, eight held low status occupations such as day

[31] Kesztenbaum and Rosenthal define rents below 300f in Paris in 1890 as low (Kesztenbaum and Rosenthal, 2016). Rents in Nancy were probably lower, but nevertheless a rent of less than 100f would be very low.
[32] Kesztenbaum and Rosenthal use 1000f to indicate a high rent in Paris in 1890 (Kesztenbaum and Rosenthal, 2016).

worker or gardener, one was a glovemaker (HISCLASS 9) and three were of medium occupational status, with one shoemaker, one hatmaker and one dressmaker (all three occupations are HISCLASS 7). In addition, one ran a licensed café (HISCLASS 4), which she presumably did in conjunction with her husband, who was a wine merchant (also HISCLASS 4). However, it is not clear if this means the other wives in the sample did not have an occupation, or that the census-takers were more concerned with recording the occupation of the head of the household.

Once the wife becomes the head of the household, following the death of the husband, she is far more often shown as having some occupation. Even if no specific occupation is given, entries for the widow are often marked as *sans profession* (without profession, indicating someone of independent means) or marked as *veuve* (widow), whereas for wives no entry was made. The description *veuve* is hard to interpret and is being treated as 'occupation unknown'. The vast majority of the 135 wives for whom I have details after the first move/year[33] have occupations listed: 97 or 72%. This increases to 104 (87%) of the 120 wives in the sample after two moves/years. The spread of occupations undertaken by widows is shown in Figure 6-3 for both the first and second periods following bereavement, and it can be seen that by far the most common occupational category is HISCLASS 11, which includes unskilled dayworkers. This is in marked contrast to the occupations of the deceased husbands, the largest category of which was HISCLASS 7 (skilled artisans), as discussed in Chapter 5. The occupational status of the widows, where available, seems to be markedly lower than that of the deceased husbands. Although undertaking paid work was clearly a route chosen by many of the widows, these data suggest their earnings were likely to be much lower than those of the husband.

[33] A new record was created if the household moved before the end of the census period, or for a new census year, whichever happened first.

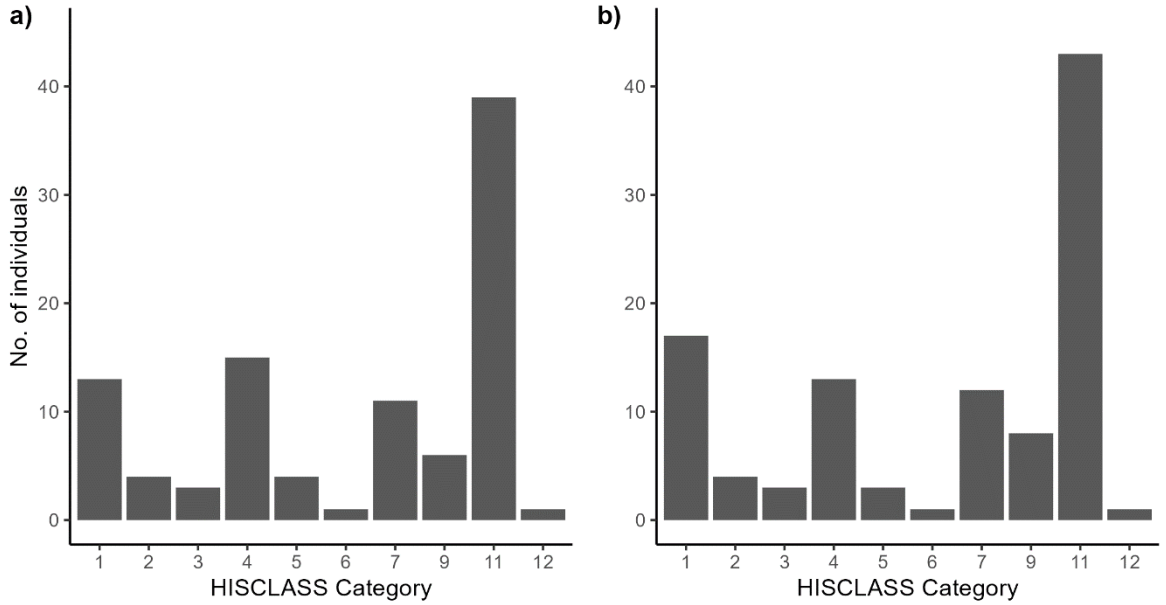


Figure 6-3. Occupation of wives following death of husband
Plots show occupations a) One move/year after death and b) Two moves/years after death.

6.4 Analysis: impact of death of breadwinner on accommodation

6.4.1 Summary of accommodation changes

We know from the literature and from data from early twentieth century France that the male breadwinner contributed the majority of the family income, so his loss is likely to have had a negative impact on the family finances. An obvious way for a household to save money following this loss would be to move to less expensive accommodation, or possibly negotiate a cheaper rent on the existing accommodation. I focus on this issue here, considering the changes for the bereaved families and comparing these with small samples of the same families prior to bereavement and of 'control' families. My findings suggest that the death of the main breadwinner led to instability in the accommodation position of the families left behind and to a small deterioration in their financial position, as proxied by rent paid. These findings are confirmed when comparisons are made with the year prior to death and with the control group.

6.4.2 Accommodation changes for families of the deceased

The Nancy dataset is a panel dataset that follows households over a number of years. The initial sample was of 161 deceased married men, and I have data for

135 households one move or one year following the death of the husband. A new record for the family could be created in two possible ways. A new record was created if the household moved before the end of the census period, which is shown in the census by their original details being crossed out and new details entered at the address to which they moved. In the sample, multiple moves within a year are rare, occurring in only two instances. A new record was also automatically created for each new census year, if the family could be found in the next census, as at a minimum there would be changes in the ages of family members as compared with the previous year. Analysis is undertaken on the first move or first year, whichever happened first.

There were 26 households, equal to 16% of the sample, lost because no information was available for the first move/year, and these were examined in more detail to see if any patterns emerged. A high proportion of households lost to the sample were childless: 65% compared to 23% of those retained. One could speculate that childless widows were more mobile and more likely to move in with other family members. This does not explain why their subsequent location is not recorded, unless census takers made less effort to collect information on this sub-group, or the women themselves did not want to be found to avoid, for example, being pursued for debts. Five residents of *garnis* were lost to the sample and only one was retained. As inhabitants of *garnis* were the people most likely to move (see e.g. Faure and Lévy-Vroelant on the *nomadisme* of this group (Faure and Lévy-Vroelant, 2007)), this is not surprising.

To assess whether the sample attrition could be a source of bias in any subsequent analysis, tests were undertaken to check whether the means (or proportions) of the 'retained' sample and the 'lost' sample were statistically different. This comparison is between 135 'retained' households and 26 'lost' households, so it should be born in mind that there is a large difference in the sizes of the two samples. Results are shown in Table 6-1. These suggest that sample attrition is not an issue when considering rent, persons per room and occupational status, which are the variables used in the main models below. However, there is a statistically significant difference between the two samples when it comes to the number of children in the family and whether the family lived in a garni. This is not surprising, in light of the discussion in the previous

paragraph. All subsequent results are therefore dependent on the family remaining in the sample. This 'retained' sample excludes most households living in the very poorest accommodation as almost all inhabitants of *garnis* are lost, and this is born in mind during the remainder of this discussion. An alternative analysis of sample attrition was also undertaken, considering the probability of a household being lost to the sample. This output is shown in in Appendix 8.5.2, Table 8-14 and supports similar conclusions to the above.

Table 6-1. Comparison of households retained in sample or lost to sample after one move/year

Variable	*Retained sample mean*	*Lost to sample mean*	*p-value*
Rent	302	226	0.35
Persons per room	2.49	2.42	0.85
HISCLASS occupation of breadwinner	6.07	6.69	0.29
Number of children	2.1	0.88	0.000
Number of children under 11	1.17	0.46	0.000
	Retained sample proportion	*Lost to sample proportion*	
Wife can continue business	0.244	0.038	0.036
Garnis	0.007	0.192	0.000
Sample size	135	26	

Notes: Output shows the results of a Welch two sample t-test for difference of means for rows one to five and a two sample test for equality of proportions for the final two variables. Analysis is undertaken for each variable individually. HISCLASS occupation is treated as cardinal.

Of the 135 households retained in the sample, 29 (21%) moved to a different address; a larger number, 54 households, experienced rent changes, so rents could alter even for those who stayed at the same address, possibly because the family had moved within the property. On average, rent was reduced by 13f, with 31 households (24%) paying less rent and, somewhat surprisingly, 23 households (17%) paying a higher rent. The most common outcome was for there to be no change in rent, which was the case for 81 households (59%) (Figure 6-4). Five of the households paid a significantly higher rent, considered here to be an increase of 200f or more. These were examined more closely.

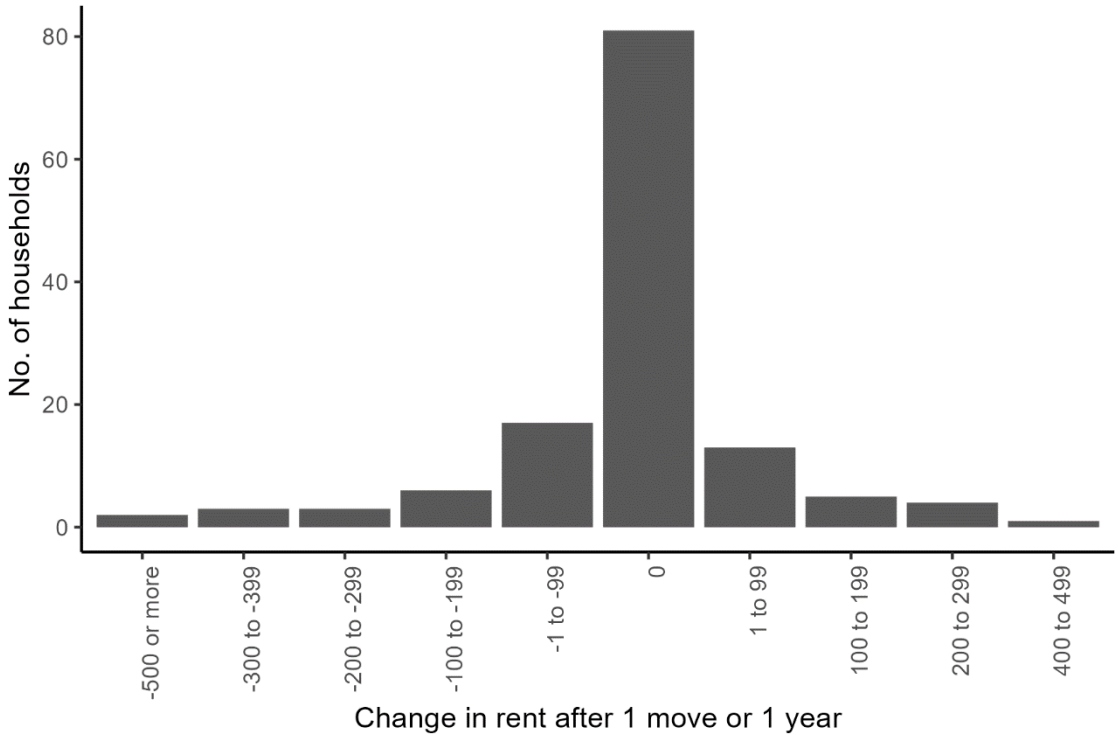


Figure 6-4. Changes in domestic rent, one year or move after bereavement
Shows changes in rent paid in francs by households where information is available between the year of the husband's death and the following year, or to the time of the first move, if sooner.

Of the five households, one family moved to the higher rent property for a brief period and then moved back to a low rent property; one took in additional lodgers, which presumably helped pay the higher rent; two households had children who took up paid occupations which would support the higher rent; and one ran a business (horse butchery) so the rent increase may in part be due to having to pay a higher business rental (the split has to be estimated).

I have records for 120 households who moved for a second time or who were found in the census in the second year following the death of the husband. Of these, 45 had moved to new accommodation since the death of the husband and 75 remained at their existing address. Over this period, there was a larger mean fall in rent than in the first move/year of 23f as opposed to 13f, with 31% paying less rent and 22% paying more. The most common outcome, for the households for which we have information, is again no change in rent, which is the case for 47% of the sample (Figure 6-5).

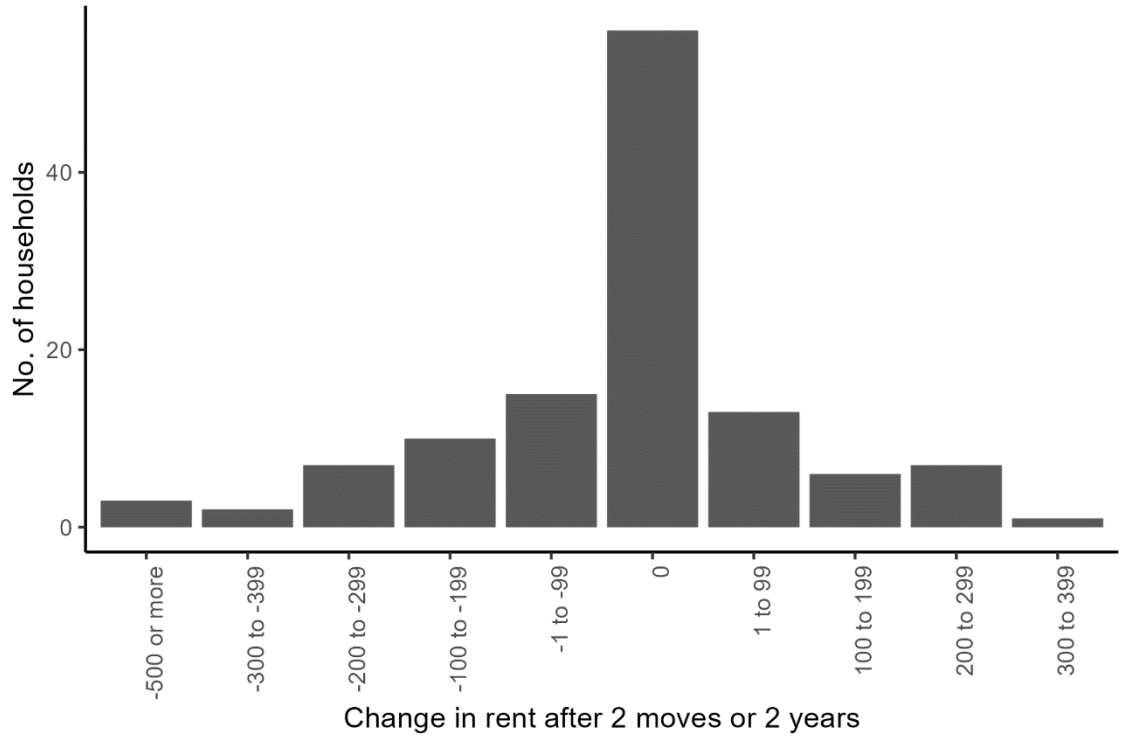


Figure 6-5. Changes in domestic rent, two years or moves after bereavement
Shows changes in rent paid in francs by households where information is available between the year of the husband's death and two years after, or to the time of the second move, if sooner.

The number of households which could be traced following the third move/year after the death of the husband is 67, only 42% of the original 161 households[34]. Of these, 35 had moved to new accommodation and 32 still lived at the same address as when the breadwinner died. There had again been a mean fall in rent of 24f, with 30 households (45%) paying less rent and 21 households (31%) paying more (Figure 6-6): note this fall in rent is between the year of death of the breadwinner and the third move/year. Although the sample is smaller, the fall in rent is very similar to that in the second move/year after the husband's death, suggesting that on average, for those families who remain in the sample, their income has stabilised at a new (lower) level.

[34] The reason for this much lower retention rate than after the first and second moves/years is that time only permitted the sourcing of data up to 1898. Possibly some of the second moves/years and certainly many of these third ones would be found in the 1899 and 1900 censuses. Data shown here for the third move/year are therefore not necessarily indicative of the number of households that survived.

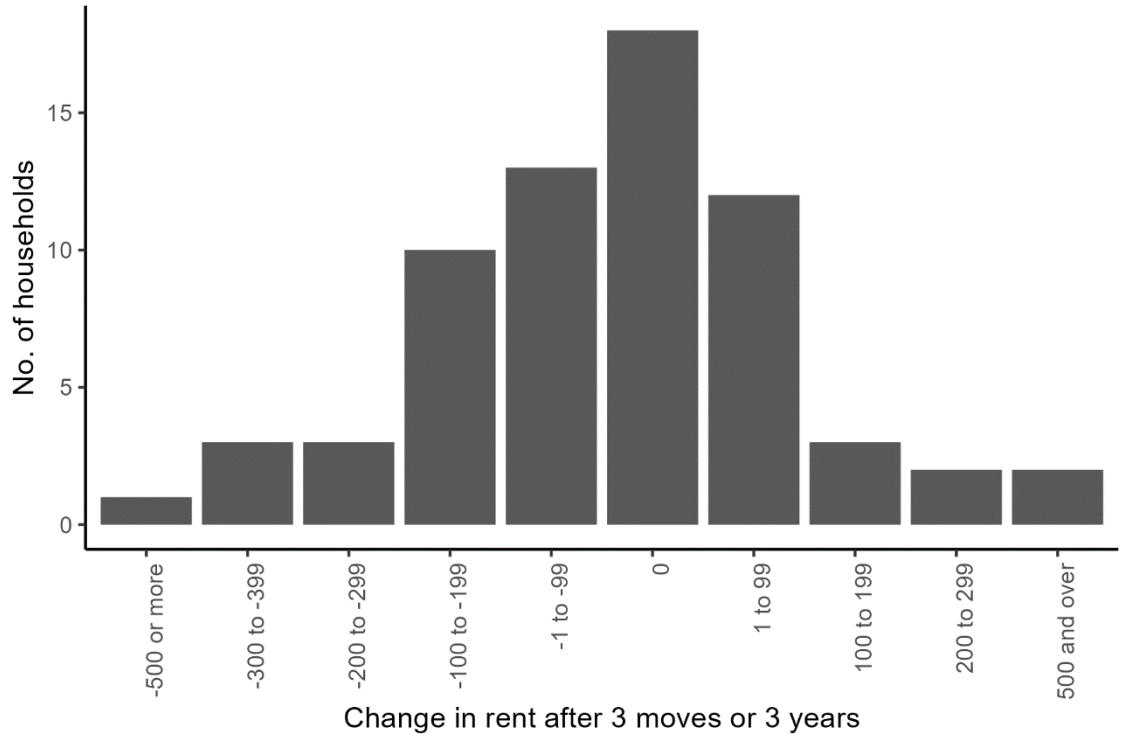


Figure 6-6. Changes in domestic rent, three years or moves after bereavement
Shows changes in rent paid in francs by households where information is available between the year of the husband's death and the third year following his death, or to the time of the third move, if sooner.

I also considered the change in the average number of rooms over the moves/years discussed above and found that the average fall in rent was accompanied by a slight fall in the number of rooms per dwelling. After the first move/year, the number of rooms per house reduced very slightly, from 2.38 to 2.34 rooms per dwelling. In the second year/move after bereavement, the average number of rooms fell further, although still only moderately, to 2.28. After the third move/year the average number of rooms per dwelling had fallen again, to 2.07. Unlike the apparent stabilisation in the rent paid by this third year, the average size of the dwelling still appears to be falling.

6.4.3 Accommodation changes prior to the death of the breadwinner

As an auxiliary investigation to supplement the analysis above, data were collected for a small sample of the deceased families in the year prior to death. This sample is constrained as it was created after the field trips to Nancy, and therefore it was only possible to source data from the 1895 census, which is available on-line. The sample therefore consists of those families of deceased

breadwinners who died in 1896 (67) or late 1895 (4), giving a total of 71 households. There is no reason why this sample should be biased, given that it covers approximately one calendar year. It is presented here for comparison, albeit bearing in mind that it is smaller than the samples for the two years following the death. Between the year prior to death and the year of death, there was a very small fall in the average rent paid of 2.7f (0.7%), with the vast majority of households (over 70%) having no change in their accommodation situation (Figure 6-7). There was also a small fall in the average number of rooms per dwelling of 0.04 rooms. The above figures suggest a very small fall in income of this group in the period prior to the husband's death. As noted previously, we have no information on cause of death, so we cannot link these changes with particular illnesses, but one could hypothesise that if the death was the result of a worsening health over a period of time, the poorer health of the husband may have encouraged some families to relocate to cheaper accommodation. The percentage of households in the sample who do not move is far higher than for any of the three moves/years following the death, suggesting that the economic situation of the families was more stable prior to than following the death of the breadwinner.

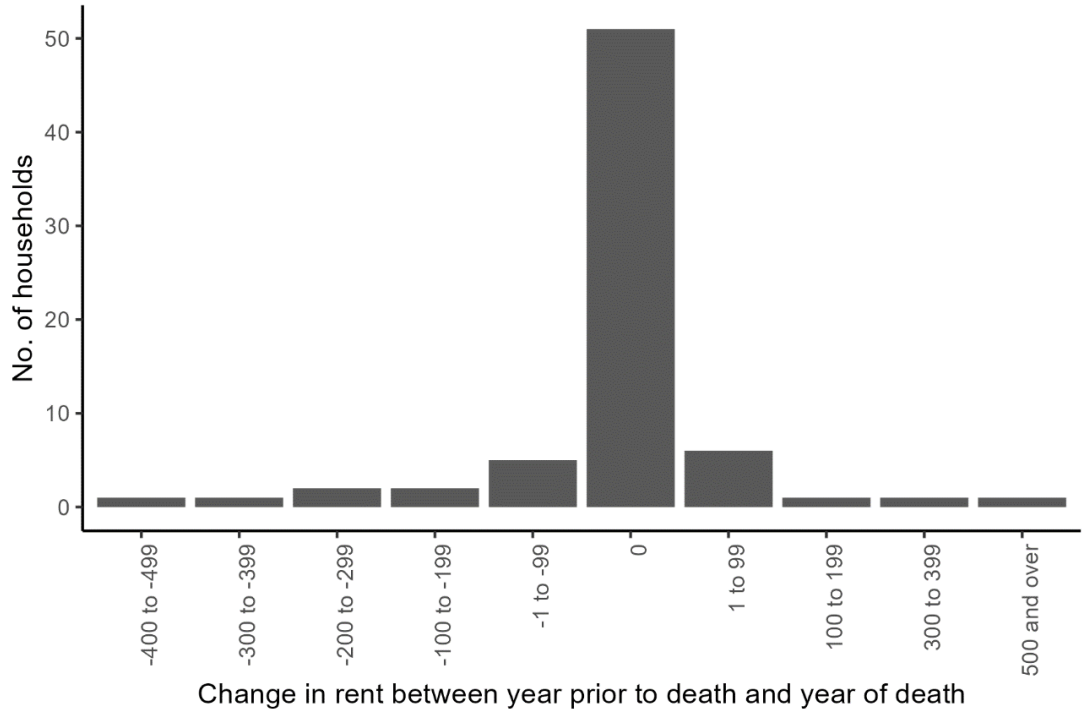


Figure 6-7. Changes in domestic rent, between year prior to death and year of death
Shows changes in rent paid in francs by households where information is available.

6.4.4 Accommodation changes of controls

A dataset containing 52 families of 'controls', that is families where the breadwinner did not die, was also created. The size of this sample is small due to time constraints towards the end of the data collection period. The method of selecting controls is described in Appendix 8.5.1. Descriptive statistics were calculated for this sample for their base year[35]. Comparing these with those of the deceased men and their families, we can see that, on average, the control families were slightly larger, with more children, fewer servants and more lodgers. The controls had a very similar average number of rooms but higher persons per room and higher average rent than the main sample (Table 6-2).

Table 6-2. Descriptive statistics for the control households, Nancy

Variable	Minimum	Maximum	Mean	Standard deviation	Mean of deceased sample
Number of household members	2	18	5.08	2.52	4.6
Number of children	0	14	2.78	2.29	1.90
Number of servants	0	2	0.14	0.45	0.08
Number of lodgers	0	1	0.06	0.24	0.12
Number of rooms in dwelling	0.50	6	2.21	1.19	2.31
Persons per room	0.75	10	2.94	2.07	2.52
Rent in francs (excluding business premises)	1	2,600	335	533	290

Notes: Data are for 52 control men and their households. Number of rooms has been imputed for five households. Rent has been imputed for 11 households without business premises and 6 households with business premises. The mean of the deceased sample of 161 households is included for comparison.

Tests were run to see if the two samples (main sample and controls) were sufficiently similar to allow meaningful comparisons. Because the distributions did not comply with normality assumptions, a Wilcoxon test was run on each of the variables in Table 6-2. The Wilcoxon test is a non-parametric test which compares distributions of non-normal samples in order to ascertain whether two independent samples are significantly different (Schwaid, 2023). The test results showed that the main sample and the control sample were not significantly different with regards to domestic rent, number of rooms, number of members of the household, number of servants and number of lodgers[36]; however, they

[35] The base year is the year when the control was selected, and is equivalent to the year of death of the breadwinner in the deceased households.

[36] For example, for domestic rent the Wilcoxon signed rank test revealed no significant difference between the two samples ($n = 213$, $W = 4303$, $p = 0.763$). A low p-value indicates a significant difference between samples (King and Eckersley, 2019).

were significantly different in terms of number of children and persons per room.

As domestic rent was one of the variables where the main and control samples did not show statistical difference, any changes in the controls' rent between the base year and the first move/year were examined, as had been done for the deceased sample. Forty-seven of the 52 controls could be traced one move/year following the base year. Six of the households moved within this time period, although eleven households experienced a change in rent. Three paid a lower rent and eight a higher one (Figure 6-8). The average change in rent was an increase of 5f. In general, therefore, it appears the controls were more likely to experience an increase in rent than the families of the deceased, where on average rents fell. The magnitude of the difference is not large, a rise of 5f compared to a fall of 13f, but it follows the pattern that might be expected with the families of the deceased being less financially well off following the bereavement compared to families who did not suffer the loss of the breadwinner. More than 75% of the control households did not move accommodation, suggesting, as with the year prior to the death of the breadwinner, a more stable housing situation than that experienced by households following the breadwinner's death.

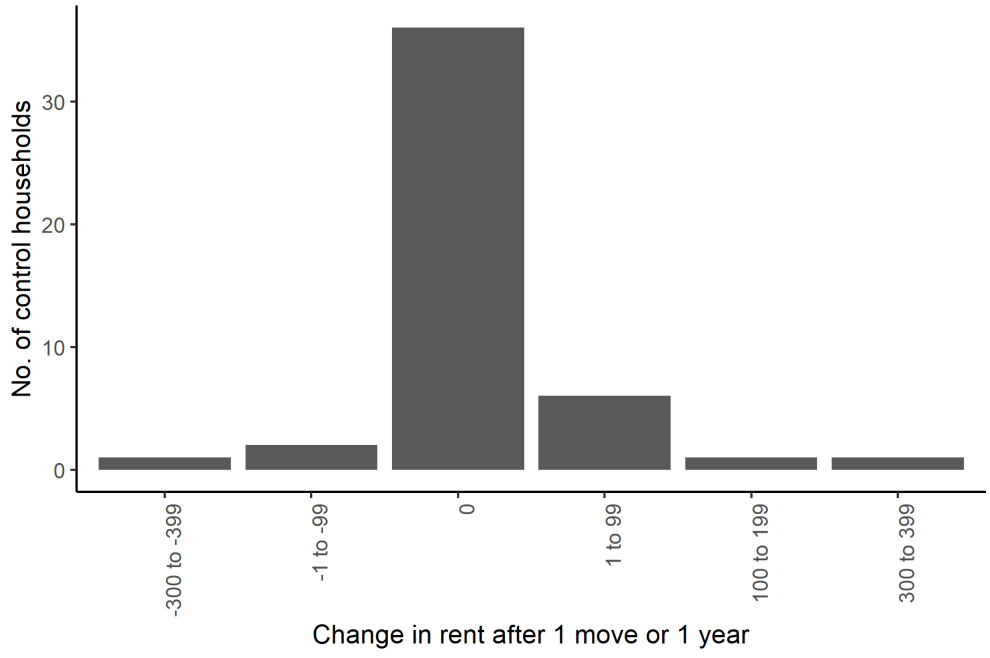


Figure 6-8. Changes in domestic rent paid by control households, one year/move
Changes in rent paid in francs between the base year and the following year, or to the time of the first move, if sooner.

Changes in rent between the base year and two moves/years after the base year were also analysed. There were 42 records in this sample, meaning that 80% of controls are retained after two moves/years, compared with 75% in the main sample. There was an average fall in rent of 17f, with the distribution of falls and increases shown in Figure 6-9. Once again, the controls performed better financially than the families of the deceased, who, by this point had experienced a fall in rent of 23f. The difference is small, but is in the direction we would expect (albeit we have no particular reason to suggest why controls are worse off financially two years on than in the base year). The average fall in rent for controls here is influenced by the move of one family, the Bastians, who move from a 6-roomed apartment in Section 5 which cost 1400f to a house in Section 8, the full cost of which is 1550f, but only 700f of this appears to be charged to the Bastians. If this one record is excluded, the mean change in rent is a fall of 26 centimes, i.e. very close to, on average, no fall in rent.

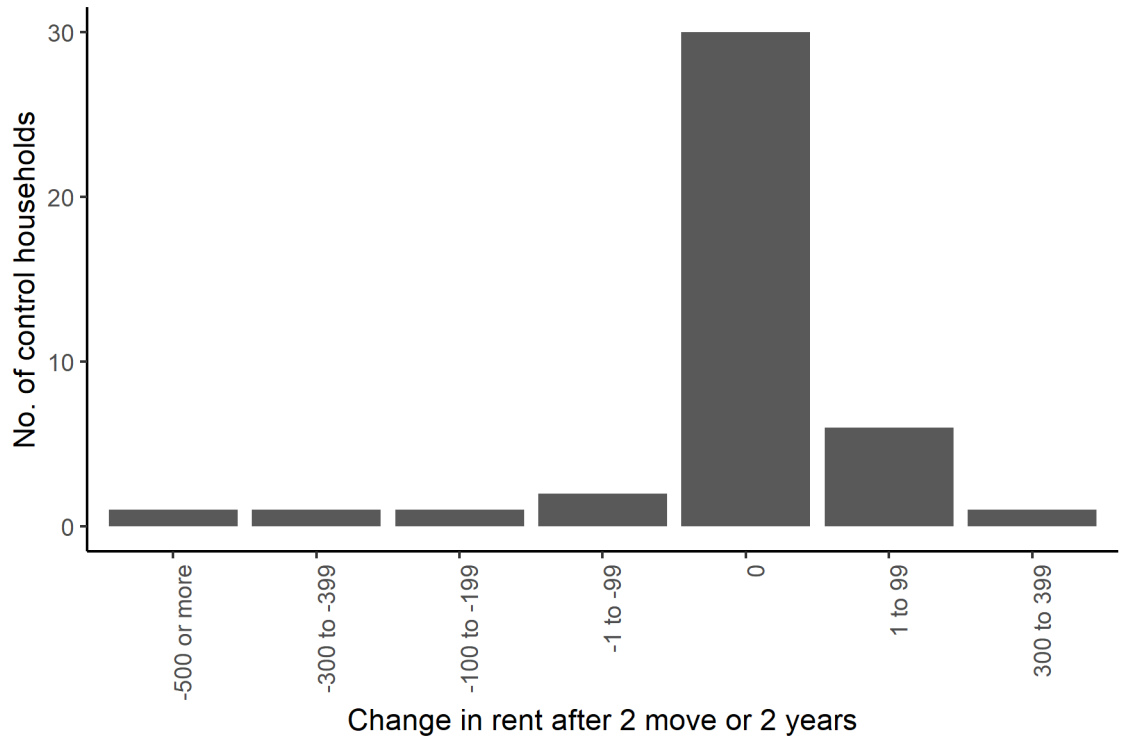


Figure 6-9. Changes in domestic rent paid by control households, second year/move
Data show the change in rent paid in francs between the year of the matched husband's death and the second year after, or to the time of the second move, if sooner.

After the third move/year, the number in the controls sample drops to eleven, a very small sub-group. The reason for this apparently sudden sample attrition is

because time pressures had become more evident and the focus of data collection was transferred to the main sample. Nevertheless, there was again a rise in rent paid compared with the base year (48f).

When considering the average number of rooms after one move/change for controls, it is interesting to note that although there were very few moves of accommodation, in those who did move this led to a slight increase in the overall average number of rooms per dwelling, from 2.1 to 2.2. This sample is smaller than that shown in Table 6-2 so the figures should not be compared. This increase in rooms per dwelling was maintained over the following two moves/years, suggesting that controls not only experienced a better financial situation than the main sample, but that they also had, on average, more rather than less spacious accommodation.

6.4.5 Summary of financial impact of loss of head of household

Analysis in this section shows that the death of the main breadwinner led to less stability in the accommodation position of the families left behind. Within the first year, if we include the families lost to the sample who clearly also moved (because their previous address was occupied by another family), almost 50% of the sample experienced some change in their accommodation status within the first year. By the second move or year, this proportion had increased slightly, to 53%, suggesting that most of the changes were experienced in the first year. The loss of the main breadwinner also led, on average, to the paying of lower rent and living in smaller accommodation, as far as can be measured for those families who remained in the sample. By the third year/move the fall in rent had stabilised, being very similar to that of the second year/move, suggesting that by this time the family had settled into a new financial situation. By this third move/year, the average fall in rent was around 10% of the rent at the time of the husband's death, so the fall, although not enormous, was noteworthy. Given that we know from other records that the average male breadwinner accounted for over 70% of a household's income in France around this time (U.S. Department of Commerce and Labour, 1909), the ability of so many households to remain intact with apparently only a small fall in income, as proxied by rent, is remarkable. It is not clear exactly how the widows managed to sustain this

standard of living, given that the occupational status of the women, where known, was generally lower than that of their deceased husbands, with the largest group being dayworkers.

Comparing the experience of families following bereavement with the year before, we find that a far smaller proportion of families moved prior to the bereavement than after it, leading one to conclude that the bereavement itself was a major contibutor to the insecurity around accommodation. In addition, if I compare the bereaved families with a small control sample who did not suffer bereavement, I find that the control families moved less and performed better both in terms of rent paid and size of accommodation. These results suggest that the financial situation of the family deteriorated in the years immediately following his death, albeit this impact was not as large as might have been expected.

6.5 Results: Are accommodation changes related to socioeconomic conditions?

6.5.1 Statistical model

As discussed in Section 6.2, research suggests that the negative impact of the loss of the father is related to the family's socioeconomic status, with higher status families coping better with this change. I have discussed how selecting cheaper accommodation is one obvious way for the widow to adjust to her changed circumstances and have shown that, on average, widows did live in cheaper and smaller accommodation following the loss of the husband. I now use the data available to test if the socioeconomic variables in my dataset are associated with these accommodation changes.

I use a similar ordinary least squares statistical model to that used in Chapter 5. The percentage change in rent following the death of the breadwinner is denoted by y, and the full statistical model is given by

$$y_{ihs} = \beta_1 + \beta_2 \boldsymbol{X}_i + \gamma \boldsymbol{Z}_h + \eta_s + u_i \qquad [7]$$

for individuals $i = 1, \ldots, N$ in household *h* = 1,…,N and section s = 1,…,M. In this specification, y_{ihs} is the percentage change in rent; $\boldsymbol{X}_i$ is a set of variables relating to the individual, including occupational status of deceased head of household; $\mathbf{Z}_{\boldsymbol{h}}$ is a set of further variables relating to the household such as persons per room, the ability of the wife to continue the business and the number of children living in the household; and η_s is dummies for the eight *sections* of Nancy; the constant term β_1 captures common factors: and u_i is an error term. Where independent variables change over time, the value for the base year (year of bereavement) is always used, although a separate specification has also been run using the *section* one move/year after the death, see below. To account for potential heteroskedasticity, I allow for the error term to be correlated within geographical areas by calculating standard errors that are clustered at the level of the *section*. As a robustness check, I also calculate standard errors that are robust to arbitrary forms of stochasticity. Additional checks are also undertaken to test for collinearity of the independent variables.

Persons per room is included in the models both as a marker of overcrowding and a possible marker of income, as poorer families were known to live in more overcrowded conditions (e.g. Cage and Foster, 2002). A higher number of persons per room would be expected to be negatively associated with the family's financial position post-bereavement. Occupational status is used in historical research as a marker of socioeconomic conditions (see Literature Review, Section 6.2). I include the occupational status of the deceased breadwinner at the time of his death, as this has been found to be associated with subsequent family outcomes, with lower occupational status impacting negatively on the family's success post-bereavement. The ability of the wife to continue the family business is specifically mentioned in previous research as being helpful for subsequent family survival, and this variable is included to test that hypothesis. The number of children living at home might be expected to impact on how well the family copes following bereavement, and the inclusion of this measure allows me to test the influence of this measure.

The *section* (that is, the area where the family lived) is included in the model to allow the identification of possible area affects. As discussed in 6.3.3, *Sections* 2

and 6 were the better-off areas of Nancy, with none of households in the sample who lived in these *sections* having low occupational status. *Sections* 4, 5 and 7 had no households where the breadwinner was of high occupational status, with *Section* 5 having the lowest mean rent of all *sections*; these three could be considered the 'worst-off' *sections*. *Sections* 1, 3 and 8 seem to fall somewhere in the middle, being neither the 'worst' nor the 'best' areas. In general, I have used the *section* the family lived in at the time of the bereavement in my statistical models, but, to test if there is a differential influence, I run alternative regressions using the *section* where the family resided after one move/year.

6.5.2 Rent changes after first year or first move

Analysis was undertaken on the change in rent after the first move/year following the death of the head of household, on whichever occurred first as discussed in 6.4.2, calculated as a percentage of the original rent[37]. A positive figure means the rent has increased and a negative one that it has fallen. Persons per room alone is included in Model 1. Occupational status is approximated as three dummies (high, medium and low) and this is included alongside persons per room in Model 2, with high occupational status being the reference category. The *section* in which the family resided at the time of death is added in Models 3 & 4 to allow for possible area effects. *Section* 2 is used as the reference *section*. Model 4 repeats Model 3 but sets low occupational status as the reference category. Output is shown in Table 6-3.

Measures of socioeconomic circumstances (persons per room and occupational status) have very little association with whether the family moves to cheaper (negative impact) or more expensive (positive impact) accommodation. In Model 2, low and medium occupational status both show no statistically significant difference with high occupational. Medium occupational status is, however, possibly associated with paying a higher rent as compared with high occupational status in Model 3, while low occupation status is still not associated with any statistically significant difference. The association with geographical location,

[37] That is, as (rent_y1 - rent_y0)/rent_y0, where y0 is the year of death of the breadwinner and y1 is the period after the first move/year.

seen in Models 3 & 4, appears stronger. Compared with *Section* 2, which is probably the highest rent area of the city, having originally lived in any of the other *sections* is associated with changing to a lower rent. This is more in line with the conventional understanding that households of higher socioeconomic status, here represented by *Section* 2, manage better than other households following the death of the head of household.

Table 6-3. Socioeconomic and other conditions and the change in rent after one move/year (1)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-0.071	-0.478*	0.446	1.177
	(0.429)	(0.200)	(0.291)	(0.718)
Persons per room	0.300	0.287	0.329	0.329
	(0.219)	(0.211)	(0.226)	(0.226)
High occupational status				-0.731
				(0.789)
Medium occupational status		0.501	0.819.	0.088
		(0.408)	(0.448)	(1.014)
Low occupational status		0.402	0.731	
		(0.636)	(0.789)	
Section 1			-1.221**	-1.221**
			(0.434)	(0.434)
Section 3			-0.581**	-0.581**
			(0.207)	(0.207)
Section 4			-2.713***	-2.713***
			(0.435)	(0.435)
Section 5			-2.193***	-2.193***
			(0.262)	(0.262)
Section 6			-1.066***	-1.066***
			(0.037)	(0.037)
Section 7			-2.326***	-2.326***
			(0.225)	(0.225)
Section 8			-1.763***	-1.763***
			(0.219)	(0.219)
R^2	0.023	0.025	0.059	0.059
Number of observations	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. Includes occupational status. Mean of the proportional change in rent = -0.044. Least squares estimate with robust standard errors clustered on section. Number of observations: 135 households; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

To test whether the influence of these geographical variables only related to *Section* 2, Model 3 was replicated setting each section in turn as the reference category (appendices, 8.5.2, Table 8-15). The 'better' *sections, Section* 2 and 6, have a positive association with the change in rent, meaning that living in these *sections* is associated with seeing an increase in rent paid, as compared with the other *sections*. The 'less good' *sections, Sections* 5, 7 and 8, all have a negative

association with the change in rent. All models have a very low R^2 value, indicating that the variables available explain only a very small amount of the change in rent.

If the above analyses are repeated including the number of children living at home, this made no difference to the results (Table 8-16). The analyses were also run using the *section* the family lives in after the first move/year rather than the one they originally lived in, the output remains similar except that living in *Section* 5 now has a positive impact on the level of rent compared with *Section* 2, with all other *sections* still having a negative impact (see appendices, 8.5.2, Table 8-17). *Section* 5 was a small, socially diverse area in central Nancy with the lowest mean level of rent. It is not clear why families choosing to move to or stay in this section would see an increase in rent.

The literature suggests that the presence of a family-run business was likely to impact positively on the future chances of the household, and a binary variable was included in the dataset to examine this. Thirty-three households were identified where the wife might have been able to continue the business, although only 31 of these households had data for the move/year following the year of death. Of the 31 households for which I have information, 26 of the wives are shown as continuing the business of the husband after one move/year, with their occupational status ranging from landlord (HISCLASS 1) to basket-maker (HISCLASS 9). The vast majority, 21, were of medium occupational status (HISCLASS 3 to 8).

Four regressions were run including the binary variable 'wife can continue business', using the same models as in Table 6-3, but also including number of children under 11 (Table 6-4). Number of children under 11 is included as this might reasonably be expected to impact on the wife's ability to run a business. Surprisingly, although the 'wife can continue business' variable does have statistical significance at the 5% (Model 1) or 10% level (Model 2), the coefficient has a negative value, meaning that where the wife could continue the family business this was associated with a fall in rent after one move/year.

Table 6-4. Socioeconomic and other conditions and the change in rent after one move/year (2)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.359	-0.063	0.500	1.218.
	(0.383)	(0.140)	(0.351)	(0.636)
Persons per room	0.424	0.411	0.458	0.458
	(0.336)	(0.338)	(0.368)	(0.368)
Wife can continue business	-0.664**	-0.696*	-0.407	-0.407
	(0.230)	(0.343)	(0.461)	(0.461)
Number of children under 11	-0.500	-0.501	-0.484	-0.484
	(0.369)	(0.379)	(0.387)	(0.387)
High occupational status				-0.718
				(0.805)
Medium occupational status		0.545	0.815.	0.097
		(0.483)	(0.484)	(1.074)
Low occupational status		0.354	0.718	
		(0.625)	(0.805)	
Section 1			-0.929**	-0.929**
			(0.312)	(0.312)
Section 3			-0.338***	-0.338***
			(0.096)	(0.096)
Section 4			-2.312***	-2.312***
			(0.289)	(0.289)
Section 5			-1.688***	-1.688***
			(0.239)	(0.239)
Section 6			-0.656**	-0.656**
			(0.219)	(0.219)
Section 7			-2.086***	-2.086***
			(0.145)	(0.145)
Section 8			-1.515***	-1.515***
			(0.164)	(0.164)
R^2	0.050	0.052	0.081	0.081
Number of observations	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. Includes whether the wife was able to continue the family business and number of children under 11. Mean of the proportional change in rent = -0.044. Least squares estimate with robust standard errors clustered on section. Number of observations: 135 households; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Looking in detail at some of the families involved, Elisabeth Gaspard, who is childless, moves from a 3-roomed house where the family paid rent of 800f at the time of her husband's death to a 1-roomed apartment costing 18f, despite continuing to work as a *cabaratière* (inn-keeper), as her husband had done. Marie Eugenie Bandt, who has three children under ten years of age, manages to negotiate a reduction in rent on the 3-roomed apartment where she lives from 500f to 300f. Adrienne Rouyer becomes *propriétaire* (owner) of the property where she lives on her husband's death. She has no children and moves to a cheaper part of the accommodation, although still living in three rooms. From these examples it can be seen that, although these women are paying a lower

rent following the death of their spouse, only one is in smaller accommodation. For this group of women, the rent paid may not be a good representation of their level of income. It may be that wives in this situation found their relatively powerful position as partly or wholly responsible for a small business meant they were better able to negotiate a lower rent.

When *sections* are added to this specification (Models 3 & 4), the statistical significance of the ability to continue a business variable disappears, and the *sections* show a similar association with rent changes as seen in Table 6-3, but with lower coefficient values. The models again have very low explanatory power. These regressions were also run excluding the number of children under 11. The coefficients remain negative, but 'wife can continue business' loses any statistical significance below the 10% level, except in Model 1. These results are shown in the appendices, 8.5.2, Table 8-18.

When dividing the occupational status of the deceased head of household into a binary option of manual or non-manual worker, having been a manual worker is associated with paying a higher rent following the first year/move, although the association is not highly statistically significant (Table 6-5). The strongest association with a change in rent appears, as with Table 6-3, to be the area effects of the different *sections* of the city. All *sections* are associated with a fall in rent compared with the reference *section, Section* 2, which is the 'best' *section* according to many socioeconomic criteria. It seems that, once again, we may be seeing the influence of socioeconomic conditions channelled via the geographical area.

When the models looking at manual status (Table 6-5) were re-run including children living at home (Table 8-19) or using robust standard errors without clustering (Table 8-21) all statistical significance at the 10% or below disappeared. Table 6-3 was also repeated without clustered standard errors (see Table 8-20) and once again all statistical significance disappears. The changes are as expected, as removing clustering reduces the precision with which the standard errors are estimated.

Table 6-5. Socioeconomic and other conditions and the change in rent after one move/year (3).

	Model 1	Model 2	Model 3
(Intercept)	-0.071	-0.349	0.974*
	(0.429)	(0.367)	(0.481)
Persons per room	0.300	0.223	0.269
	(0.219)	(0.228)	(0.254)
Manual occupational status		0.794.	0.824.
		(0.418)	(0.452)
Section 1			-1.389***
			(0.222)
Section 3			-0.838***
			(0.146)
Section 4			-2.779***
			(0.437)
Section 5			-2.096***
			(0.208)
Section 6			-1.011***
			(0.020)
Section 7			-2.396***
			(0.195)
Section 8			-1.970***
			(0.127)
R^2	0.023	0.033	0.065
Number of observations	135	135	135

Notes: Estimates shown for the specification in equation [7]. Includes manual as opposed to non-manual occupational status. Mean of the proportional change in rent = -0.044. Least squares estimate with robust standard errors clustered on section. Number of observations: 135 households; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Checks were also run to test for collinearity between the explanatory variables. There is no evidence of collinearity, with all variance inflation factors being below 2 (see appendices, 8.5.2, Figure 8-12).

6.5.3 Rent changes after second year or second move

The above initial analysis (Table 6-3) was replicated considering the rent paid by the family two moves/years after the death of the head of household, compared with the rent at the time of death (Table 6-6). The impact of medium occupational status as compared with high status was more strongly associated with an increase in rent than in the first year, being significant at the 5% level, but again shows no statistical difference when compared with low occupational status. If I compare high and medium occupational status against low status, there was no statistically significant association between the rent change and status. The association of the *section* lived in at the time of death and rent

changes was similar to the situation following the first move/year, except that *Section* 3 now showed an increase in rent compared with *Section* 2, with significance at the 10% level. *Section* 3 is one of the larger sections which falls neither into the 'better' or 'worse' groups of areas. Once again, the models have very low explanatory power.

Table 6-6. Socioeconomic and other conditions and the change in rent after two moves/years (1)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-0.074	-0.468*	0.336	1.148*
	(0.304)	(0.204)	(0.754)	(0.449)
Persons per room	0.295	0.289	0.369	0.369
	(0.239)	(0.226)	(0.251)	(0.251)
High occupational status				-0.811
				(0.852)
Medium occupational status		0.495*	0.972*	0.161
		(0.223)	(0.421)	(0.493)
Low occupational status		0.232	0.811	
		(0.674)	(0.852)	
Section 1			-2.288***	-2.288***
			(0.261)	(0.261)
Section 3			0.107.	0.107.
			(0.056)	(0.056)
Section 4			-2.981***	-2.981***
			(0.490)	(0.490)
Section 5			-2.422***	-2.422***
			(0.170)	(0.170)
Section 6			-1.113***	-1.113***
			(0.035)	(0.035)
Section 7			-2.444***	-2.444***
			(0.173)	(0.173)
Section 8			-1.923***	-1.923***
			(0.069)	(0.069)
R^2	0.027	0.029	0.118	0.118
Number of observations	120	120	120	120

Notes: Estimates shown for the specification in equation [7]. Mean of proportional change in rent = -0.083. Least squares estimate with robust standard errors clustered on section. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Examining the influence of being in a manual occupation instead of using the three occupational status dummies, no statistically significant association was found between manual occupations and changes in rent at the 10% level or below (Table 6-7). All *sections* except *Section* 3 are associated with a fall in rents compared to *Section* 2, so we continue to see strong area effects.

Table 6-7. Socioeconomic and other conditions and the change in rent after two moves/years (2)

	Model 1	Model 2	Model 3
(Intercept)	-0.074	-0.328	1.144
	(0.304)	(0.366)	(0.698)
Persons per room	0.295	0.228	0.324
	(0.239)	(0.205)	(0.235)
Manual occupational status		0.692	0.662
		(0.652)	(0.588)
Section 1			-2.527***
			(0.276)
Section 3			-0.259
			(0.157)
Section 4			-3.168***
			(0.587)
Section 5			-2.496***
			(0.142)
Section 6			-1.204***
			(0.014)
Section 7			-2.591***
			(0.225)
Section 8			-2.235***
			(0.125)
R^2	0.027	0.034	0.119
Number of observations	120	120	120

Notes: Estimates shown for the specification in equation [7]. Includes manual as opposed to non-manual occupational status. Mean of proportional change in rent = -0.083. Least squares estimate with robust standard errors clustered on section. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

These regressions were also run including number of children living in the household at the death of the breadwinner. This addition made no appreciable change to the results. This output is shown in Appendix 8.5.2, Table 8-22 (occupational status) and Table 8-23 (manual/non-manual occupations). After the second move/year, the ability of the wife to continue the business still had a negative association with the change in rent but was no longer statistically significant. The models in Table 6-6 and Table 6-7 were also run with only robust standard errors, not clustered. As after the first move/year, only medium occupational status was associated with the change in rent (appendices, 8.5.2, Table 8-24) and all statistical significance at the 10% or below disappeared when considering manual occupations (appendices, 8.5.2, Table 8-25).

Due to sample attrition, regressions were not run on the third move/year after the death of the breadwinner.

6.5.4 The complex influence of socioeconomic variables

The impact of the death of the main breadwinner on the subsequent household in my Nancy sample does not clearly follow the pattern expected from the published literature, which suggests that families with higher socioeconomic condition cope better with this loss. Previous research looked at mortality of family members or the adult occupational status of paternal orphans following bereavement, rather than directly at accommodation changes, as I do. Nevertheless, the suggestion is that, for example, increased childhood mortality following paternal loss was due to a loss of financial resources. My findings, examining rent changes following bereavement, find no direct association between higher socioeconomic conditions and the ability to maintain or improve accommodation choices. Where there is a statistical association with occupational status, this appears to show that the family of a breadwinner of medium occupational status coped better financially than if he had been of high status. This association is, however, only seen at the 5% or 10% level of significance. These findings are borne out for one year/move and two years/moves after his death. Manual occupational status is associated with an increase in rent paid in the first year at a 10% level of significance but has no statistical relationship with the change in rent in the second year. A possible explanation is that the families of high occupational status men may have had more scope to reduce the rent they paid for their accommodation, while still remaining in a reasonable property, than those of medium occupational status. This could account for the apparent lack of association between high occupational status and rent changes.

The results shown above are, of course, conditional on the family remaining in the sample. We know from earlier discussion (Section 6.4.2) that residents in *garnis* were far more likely to be lost to the sample than other groups, meaning that a large proportion of the very poorest people (as judged by their accommodation) are not included in the statistical models above. The apparently paradoxical relationship between medium occupational status/manual occupations and changes in rent may therefore result from losing these – and possibly other very poor families – from the sample.

A strong association is found between the percentage change in rent and the *section* within Nancy. Socioeconomic factors do appear to play a part here, as households living in all areas compared to *Section* 2, the 'best' part of the city, were likely to experience a fall in rent, so it is possible that socioeconomic conditions are acting via these geographical influences. For example, rents in *Section* 2 always and *Section* 6 usually increased as compared with all other *sections* one year after the breadwinner's death (see appendices, 8.5.2, Table 8-15). *Sections* 2 and 6 were the highest status areas, so this finding would support the hypothesis that higher status households coped better with a bereavement than lower status ones. This seems to indicate an area effect providing a class-related advantage, over and above the measures at the household level that are included in the regressions. One could hypothesise a higher level of neighbourhood cohesion or different community composition that lead to greater support (see e.g. Reid et al., 2023), or it may be the impact of some other locational characteristic such as influential clergy or other leaders who promoted certain types of behaviour. It is also possible that the level of inequality within *Sections* 2 and 6 was lower than elsewhere, as indicated by their having no households in the sample with low occupational status. Lower levels of inequality have been associated with improved community cohesion and a range of better economic and health outcomes (see e.g. Pickett and Wilkinson, 2010). As discussed above and in Section 6.5.1, it is likely that unknown factors existed that created a similarity between households within the *sections*, which is why it is appropriate to use clustered errors, as shown in the main tables.

If we view socioeconomic conditions as acting via geographical location, my results are more aligned with the published literature, although it is not clear exactly how these influences work. A possible approach would be to introduce an interaction term between area and markers of socioeconomic status. I tested this by creating an interaction term, considering occupational status alongside geographical area split into two groups (*sections* 2 and 6, which were the better off areas; and all other *sections*). However, the output produced had no statistical significance. For information, these results are included in the appendices, Table 8-26. This would suggest that currently the causes of the association of changes in rent with geographic area are hard to identify within this dataset.

My models did not show that running of a small family business had a positive impact on the bereaved households in terms of paying higher rent, despite suggestions in the literature that these households were best placed to cope with the breadwinner's death. On average, rents within this group fell. It may be that these households were in a better position to negotiate over rent than other households: six of the 31 changed to paying a lower rent, despite staying in the same accommodation. It would seem, therefore, that these households suffered an apparent negative impact on their accommodation, because rent is lower, but that this did not necessarily represent a real fall in accommodation standards.

Overall, the above models do not explain a large proportion of the changes in rent, with the highest R^2 value being 0.12 for models excluding the number of children and 0.17 for those including this variable. It appears, therefore, that despite the amount of socioeconomic information available in the censuses, there are other influences at play that impact on a family's ability to cope following the death of the breadwinner. This is an area that future research might explore.

6.6 Other impacts of the death of the breadwinner

6.6.1 Family deaths following the loss of the breadwinner

Much of the research discussed in the literature review in Section 6.2 focussed on whether the loss of the father increased the risk of death for other family members in subsequent years. I do not currently have sufficient information to make a comparison of deaths in the bereaved families against death in other families living in Nancy. However, observations can be made about the experiences of the 161 bereaved families.

In the year immediately following bereavement, three widows died, being 1.9% of the sample. This is higher than might be expected as death rates for women in this age group were about 1% per year. The youngest to die was 35-year-old Aline Gros, who took over her late husband's occupation of file maker (HISCLASS 7) but died six months later. She left behind a fourteen-year-old son who then

moved to live with his aunt and uncle in nearby accommodation. Thirty-seven-year-old Marie Henne died just over a month after her husband. No occupation is given for her, but her husband was a day worker (HISCLASS 11). They had no children living at home. Thirty-eight-year-old Marie Claire Josephine Didier died three months after her husband. He was a paver (HISCLASS 9) and she was listed as a day worker (HISCLASS 11) when she died. She also had no children living at home. Due to the lack of available information on cause of death, it is not possible to say if any of these deaths were related to those of the husband, for example being from the same infectious disease. In this very small sample, it appears that low occupational status is correlated with the likelihood of death in the first year, with two of the three women being in this group; however, the number of deaths is far too small to make any generalised statements.

Three widows are known to have died between the first and the fourth year following the loss of their husband. These are Marie Sophie Zimmerman, who had no children, and died between one and two years after her husband, at the age of 30. Her husband was a mechanic (HISCLASS 7) but she is not shown as having any occupation herself. Adelaide Chevreux, aged 48, died within four years of her husband's death. She is listed in the census as a day worker and lived in a 2-roomed apartment with her four children, three of whom were grown up and shown to be employed themselves. Anne Lettu, aged 39, also died in the fourth year following her husband's death. She is listed as a day worker and lived in a *garni* with her grown-up daughter Emelie, three younger children and one granddaughter, who is the illegitimate child of 22-year-old Emelie. In what is again a very small sample, the woman herself being of low occupational status such as a day worker appears to be associated with a higher chance of dying.

Two children died in the year following the death of the father. One-month-old Charles Wacquant was born the month after his father died and died himself at the age of five weeks. His father, Ferdinand, had been a shoemaker (HISCLASS 7) and his mother was a washerwoman (HISCLASS 11), and the couple had two older sons, aged 12 and 10. When the wife re-married a year after her husband's death, these sons were sent to the *Hospice Saint-Stanislas*, which took in children who had been abandoned by their parents, either temporarily or

permanently (Francearchives, 2023). Felicien Zehren was also born in the month after the death of his father, Jean Mathieu, a file maker (HISCLASS 7), and died at the age of nine months. Both these fathers, Ferdinand and Jean Mathieu, had medium status occupations so the families would not be expected to be at particularly high risk of an infant death (see e.g Derosas 2002), although both families lived in accommodation paying less than 20f per year, which would be indicative of a low income. Approximately nine months after Felicien's death his mother, Madelaine Penneaux, aged 29, remarried. She had two older surviving children from her first marriage, who continued to live with her and her new husband, a miner. The couple went on to have five further children.

Marie Louise Feltz was also born after the death of her father, Isodore. She lived just over a year before she, too, died, in March 1898. Her father had been a joiner and her mother was a day worker. The family also lived in accommodation for which they paid less than 20f rental, so a very low rent. They had two other sons and two daughters under the age of ten. The older daughter, Jeanne, is marked '*à Stanislas*' immediately following the death of the father and the second daughter, Marcelle, appears to join her there the following year. It seems that these children were *enfants assistés* (taken temporarily into care) as opposed to *enfants abandonnés* (wards of the state, whose parents could not reclaim them), as, in the 1906 quinquennial census, the family are marked as all living together again. The children are now aged between 12 and 18 years, and all are working or apprenticed.

Stanislas Pariset died at the age of five, two years after the death of his father Charles, a day worker. His mother was also a day worker and had two other surviving children living at home, aged 13 and 22. In the six years prior to the husband's death, this family had lost three other children below the age of one. This means that of the six children the family are known to have had, four died in childhood, three before and one after the death of the father. Even in a time of high infant and child mortality, this was an unusually high death rate.

Only one other family was found to have lost a child within five years of the death of the father. This was 21-year-old Camille, daughter of Joseph Blaise, a joiner, and his wife Marie Camille, who is initially listed as 'without profession'

but in later census entries is a day worker. Camille died 18 months after her father. During this period the family moved four times, going from a three-roomed apartment with a rent of 324f at the time of his death to a series of two- and then one-roomed apartments, the last of which had a rental of only 15f.

The number of children dying within five years of the death of the father is too small to make any definite analysis of the connection with, for example, the occupation of the deceased father. However, no children of high occupation fathers died, which may imply that an association with occupation might be found if the sample size was larger.

6.6.2 Taking up an occupation

As discussed in Section 6.3.3, far more widows appear to be employed following the death of the husband than were when he was still alive. Clearly, earning money themselves was one solution to the drop in the household income they would no doubt be experiencing. The fact that the number of employed wives increases from 72% of the sample one move/year after the death to 87% two years/moves after the death suggests that the number of women who were forced or chose to take up an occupation increased as time went on. One possible explanation for this is that charitable or family support may have been more forthcoming soon after bereavement, but that once a period of time had passed the widow was expected to manage for herself.

The earnings of the widow were likely to be much lower than those of the husband who had died. The most likely occupation for a woman was in HISCLASS 11, which comprised day labourers or similar, meaning they had no permanent employment. This may have been a choice in that these women were presumably balancing the job of running the household as well as working, but is probably more likely to do with the relatively low level of qualifications they are likely to have had. Secondary education for girls was only introduced in Nancy in 1900 (Picavet, 1899) and the skilled occupations that women are shown to have focussed on dress-making and similar activities. Taking over the running of a family business, which 26 women did, would appear to have been a better

option than was available for other widows, despite the fact that the analysis above showed no statistical relationship between this and changes in rent. More extensive work on the occupation of widows is being undertaken as part of a joint project, for example work on assortative mating in Nancy in the 1890s (Stewart et al., 2024).

6.6.3 Remarriage

Remarrying was another option for replacing the financial resources lost due to the death of the main breadwinner. Proportionately very few women remarried soon after being widowed, with only five (3%) of the original 161 widows known to remarry in the first year following the spouse's death. The youngest was Berthe Marotte, aged 24, who had a two-year-old son. Following the death of her husband she moved from a three-roomed to a one-roomed apartment and the new family remained in this much smaller accommodation despite the remarriage. Within six months of her new marriage she gave birth to a daughter. A second widow who remarried was 38-year-old Salomé Durandel, who had six children living at home aged from four to eighteen; she married 46-year-old Louis Orpheuille who brought with him three children. Within a year, one of Louis' children had left home and the couple had a new son. This is one of a number of examples of a 'composite' family found in my sample, where a widow and widower marry and join their two families. The existence of such families is to be expected given the relatively high rate of widowhood at this time[38]. This family of eleven continued to live in the 3-roomed apartment in *Section* 4 originally occupied by the widow and her six children. The remaining three widows who remarried within one year were all in their early thirties and had no children living at home.

Rates of remarriage increased two to three years following the death of the husband, with nine wives (6%) remarrying in the second year and eight (5%) in the third year. Of those wives who remarried in the second year, four had no children living at home and two had only one child. Of those remarrying in the third year, six had no children. Remarriage was known to be more likely if there

[38] A study in nineteenth century Belgium found that 10% of the sampled population had lost a partner by the time they reached their early forties (Alter et al., 2002).

were fewer children living at home. For example, Faron and Renard studied remarriage as one of the 'repercussions' of the demise of the father in the late eighteenth and early nineteenth centuries in Vernon, Normandy and found that 58% of childless widows remarried, while only 21% of widows with four or more children did so (Farron and Renard, 2002). The findings in my sample appear to support this hypothesis, although the numbers involved are small.

By 10 years following the death of the husband, 37 wives (23%) are known to have remarried. This may be an underestimate, as some of those lost to the sample may also have remarried but not appeared in the records I searched[39]. It seems probable that around a quarter of women in my sample remarried, so not remarrying was by far the most likely outcome. This remarriage rate is lower than that found in Vernon, 1790-1830 (Farron and Renard, 2002), but similar to that in an urban part of Belgium 1846-66, where 18% of widows remarried within five years (Alter et al., 2002).

6.6.4 Migration

Migration, by which I mean moving away from the town of Nancy and therefore no longer to be found in the censuses of the city, was also a way for families to cope with the financial loss of the main breadwinner. Evidence suggests that the move was usually either to other areas close to the city, or to a place with more opportunities. A relatively small number of families are marked as leaving Nancy, with ten families departing within three years of the death of the breadwinner, which is 6% of the sample of 161.

Within my sample, migration was most common in the year immediately following the death of the breadwinner. In this first year five widows leave their existing homes and move out of the city: Antoinette Bohin and family move to Besançon, Marie Baudot moves to Lagarde (45km east of Nancy), Marie Hager and family move to Paris, Marie Jeanne Dieder and family move to Reims and Stephanie Simon and family move to St Hélène (75km south). Following their first move within Nancy, two further families move away: Anne Morriset and

[39] Changes and/or inaccuracies in the spelling of names make it impossible to be sure I have a complete record of remarriages.

family move to Mirecourt (50km south of Nancy) and Josephine Toussant and family move to Ligny-en-Barrois (70km west of Nancy). Two years after the death of the husband, Marie Anne Munier and family move to Malzeville, on the outskirts of Nancy, and Catherine Ludwig and family move to Metz, 55km north. Elisa Richert, who has no children, moves to Belgium, which was her husband's place of birth, three years after his death.

The majority of the families who chose or were able to migrate were of higher socioeconomic status. Of the five who left Nancy as their first move following bereavement, three had husbands of high occupational status and two of medium occupational status: this means that 25% of the widows of high occupational status breadwinners migrated, 2% or medium occupational breadwinners migrated and no widows of low occupational status breadwinners did so. Of those who moved subsequently, four had husbands of medium occupational status (4% of this group) and one of low occupational status (also 4%). Having high occupational status, and therefore presumably access to greater resources, appears to have facilitated migration, particularly in the year immediately following bereavement. This finding aligns with evidence from late nineteenth century Devon, where 21% of the widows of gentlemen and professionals migrated, as compared with 12% of the widows of labourers and 6% of the widows of tradesmen (Wall, 2002).

Apart from the move to Belgium, and the move to Paris, which at this time was known to attract a large number of migrants, all the migrations are within eastern France, relatively close to Nancy. As indicated above, most were less than 100km distant, and even the furthest, Besancon and Reims, were only around 200km away. Ideally migration would be tracked for five or even ten years following bereavement, but, unlike marriage records, which can easily be traced on-line, migration has to be traced either via the annual Nancy censuses (currently consulted to 1898 only), or from the quinquennial national censuses, most of which are difficult to consult as they have not yet been indexed[40].

[40] Only the 1872 and 1906 censuses are currently available in a searchable format on Filae. A project is underway to digitise the censuses for 1911, 1921 and 1931, but these are not yet available for all areas.

6.7 Discussion: Impact of the loss of the breadwinner

In Nancy in the late 1890s, the death of the main breadwinner of a family had a negative impact on the family's financial situation, as indicated by changes in the level of rent paid. However, given that the breadwinner was likely to have accounted for more than 70% of the family's income, for those families who remain in the sample the drop in terms of rent was relatively minor, being around 10% after three years for those families who could be traced. The accommodation situation for families was far less stable after the death of the breadwinner than before, with over half of the families changing lodgings in the year following the death compared to around 30% in the year before. Only around a quarter of the control families moved in the year after their base year, showing their living arrangements were also more stable. The move to cheaper accommodation and the less stable living situation are in line with the literature, which has found numerous negative impacts that result from the loss of the breadwinner. However, no other studies have examined in detail the financial or accommodation impacts in the years immediately following his death and my results here are possibly unexpected, with the loss of the income of the father only leading to a relatively modest reduction in rent paid.

The household level measures of socioeconomic conditions are not associated with accommodation changes in the manner most often suggested by the current literature: persons per room and high and low occupational status having no statistically significant association with changes in rent. As discussed in Section 6.2, the size of my sample is similar to that used in many other studies so should not impact on my findings. Sample attrition may have some influence, as those most likely to be lost to the sample after the year of death of the breadwinner were some of the poorest members of society (e.g. those living in *garnis*). My results are, therefore, conditional on the family remaining in the sample. When status did appear to be associated with rental changes, for the families of medium occupational status and, possibly, manual status workers, the association was the opposite of that which might be expected: families of medium status workers were slightly more likely to increase their expenditure on rent than high status families, and the families of manual workers possibly more likely to increase their spending than those of non-manual workers. My results

here differ from existing studies, in what is currently a small literature, with most suggesting that lower socioeconomic conditions make it more difficult for a family to cope following the loss of the breadwinner. Some studies have, however, found no impact of socioeconomic conditions (e.g. Debiasi et al., 2021). My findings contribute to an area where there is currently no definite consensus.

It may be that socioeconomic factors worked partially via area effects. The *section* in which a family lived is associated with changes in rent, with families living in *Sections* 2 and 6, the highest status areas of the town, being less likely to experience a fall in rent than families in any other *section*. It is not clear why area effects are picking up the impact of socioeconomic conditions when individual household measures are not. There is more to be studied on this topic and it is perhaps not yet possible to draw conclusions on the importance of socioeconomic conditions for mitigating breadwinner loss and the channels via which this worked.

Other changes to the family following the father's death were briefly considered, and these were in line with what we would expect from the literature. Deaths, particularly deaths of widows, appear more likely in the families of low occupational status breadwinners. The likelihood of the wife going out to work increased following widowhood, and the types of occupations taken up tended to be low status ones. Remarriage was more likely if there were no children or only one child. Migration was an option only pursued by around 6% of families, with the widows of high occupational status individuals more likely to move following bereavement. Migration was principally to other areas in eastern France, relatively close to Nancy.

The unique Nancy dataset offers the opportunity to examine the changes that families faced in the years immediately after the death of the breadwinner. Work to increase the sample size, particularly for the second and third moves/years after bereavement, would enhance this work and may strengthen statistical findings. Increasing the number of control families would also provide the opportunity to build on the work undertaken to date.

This dataset has allowed an examination of how families in Nancy in the 1890s coped with the financial shock of the death of the breadwinner. It provides an indication of the mechanisms available to families to mitigate income and health shocks in a period where social insurance to deal with such shocks was very limited. My findings add to a small body of work where there is not yet a consensus on the impact of socioeconomic factors following the death of the breadwinner, and more work is needed to understand this. For example, it may be that socioeconomic conditions matter differently in different places, or that they matter far more for the very poor than for others. Other areas that seem promising for further study are the position of wives who took over the family business, who seem to be in a better position to negotiate a lower rent for the same accommodation, and to test what factors do influence changes in the families financial position (as proxied by rent), given that variables included in the model to date determine only a small proportion of this change.

Chapter 7 Conclusion

Inequalities in health have existed throughout history and their association with socioeconomic conditions has been shown to occur as early as the sixteenth century (e.g. Cummins et al., 2016) and consistently from around 1750 (e.g. Antonovsky, 1967). My thesis explores the relationship between health and socioeconomic conditions in the three European cities of Glasgow, Manchester and Nancy in the late nineteenth and early twentieth centuries. This was the period during which they were undergoing the mortality transition, which describes the change from sustained high to sustained low death rates. In order to undertake my analysis, I created three unique new datasets, which enabled me to study the historical relationship between socioeconomic conditions and health inequalities in ways that shed additional light on this important period.

My work in Chapter 2 shows that the variation in mortality rates among the small areas of Glasgow and Manchester was strongly associated with initial socioeconomic conditions, with lower socioeconomic conditions being linked to higher mortality. One of the strengths of my work is the existence of a selection of socioeconomic variables for the small areas into which the cities were divided. The three variables available for Glasgow show that population density, persons per room and the percent of illegitimate births all have a positive association with average mortality over the period 1891-1937, but that only the latter two appear to influence end-of-period mortality (1933-37). In Manchester, population density and the percent of illegitimate births influenced both average mortality levels and end-of-period mortality, which here is 1920-24. These findings link high population density with high mortality rates, which may result from such things as a lack of open space and/or increased levels of pollution; this association was found to be long-lasting. They also indicate that whatever it was that was represented by the percent of illegitimate births, which the literature suggests may be deep-rooted attitudes and concepts of risk, may also be long-lasting and possibly less amenable to policy interventions. The association between these measures and subsequent mortality was remarkably persistent, lasting forty or more years. The long-term negative impact of low socioeconomic conditions on health (here, specifically mortality) suggests that policies to tackle socioeconomic inequalities should begin as soon as possible.

In Chapter 3, I show that when a sufficiently long data series is available, the dynamics of falling mortality rates are well-represented by a sigmoid pattern that can be fitted by a logistic function. This allows the identification of key parameters such as the inflection year and the slope of the curve at the inflection point. I show that small areas with higher initial socioeconomic conditions saw rapid falls in mortality first, probably because they were able to access the relatively high-cost benefits of, for example, indoor plumbing, more space and safer nutrition. This meant that for a period there was divergence between high and low mortality areas, and this gap only closed once the lower socioeconomic/higher mortality areas themselves experienced the mortality transition. From my data, this convergence appears to start around or after the First World War. An analysis of the coefficient of variation of mortality rates for small areas of Glasgow and Manchester confirms these finding of divergence followed by convergence, and also shows that convergence remained incomplete. Socioeconomic inequalities appear to have contributed to a widening of mortality inequalities in the early twentieth century, suggesting that policies to reduce these inequalities could have reduced mortality inequalities and overall mortality. Such policies might include ensuring that the benefits of new technologies (such as indoor plumbing in the Victorian era) should be extended to the whole population as soon as possible.

In Chapter 4, I examined the association between socioeconomic conditions and attitudes towards vaccination, which was one of the few areas of health care in Glasgow in the early twentieth century where parents' decisions were largely unconstrained by income. Once objection to vaccination became legal in Scotland after 1907, higher rates of vaccine refusal were strongly associated with lower socioeconomic conditions and in particular with higher persons per room, a marker of lower income. The influence of this variable increased over time both before and after the First World War, suggesting that the attitudes that it represented became more entrenched. As we know from the literature that lower socioeconomic conditions are associated with higher rates of vaccine hesitancy in the modern day (e.g. Bocquier et al., 2017, Kohlhammer et al., 2007), my findings suggest that this relationship has existed for over a hundred years, which may indicate the presence of deep-seated social structures.

The dataset created for the city of Nancy focussed on the death of a sample heads of household from 1895 to 1897 and was made possible by the exceptionally detailed censuses conducted in that city. Unlike most censuses which are quinquennial or decennial, the Nancy censuses were undertaken annually. In Chapter 5, I showed that the occupation of the breadwinner was associated with his age at death, with men in lower status occupations likely to die at a younger age. This influence was separate from other effects relating to socioeconomic conditions such as overcrowding or income. Overcrowding, which has been linked in the literature to higher rates of death in childhood, appeared to have no association with age at death in this sample of adult men. Income also had far less influence on age at death than occupation, suggesting that these two variables should be analysed separately where possible. Using this same dataset, in Chapter 6 I was able to examine the impact of the loss of the breadwinner on the family left behind. I show that these families suffered higher levels of accommodation instability than they had in the year prior to the breadwinner's death, and higher levels than a group of control families. I also show that these families tended to pay a lower rent than when the breadwinner was alive, although as the breadwinner probably accounted for over 70% of the family income, the fall in rent was relatively modest, at only 10%. The association of socioeconomic factors with how the family coped following bereavement was less clear, with the occupation of the deceased breadwinner, family size and the ability of the wife to continue the family business all showing no clear association with changes in rent following bereavement. The strongest influence on these changes appeared to be the area of Nancy in which the family resided, with families in better areas more likely to see increases in rent compared to families in other areas. This may indicate that socioeconomic conditions are acting via local neighbourhood networks.

Throughout this thesis I have tried to take into account possible limitations of the work conducted and explore ways of mitigating these, for example by using robust standard errors to correct for small sample sizes and conducting extensive robustness analysis. In addition to these issues, it is worth highlighting other more general limitations of the work undertaken. Because I am using historical data, I was constrained by what was recorded at the time. Certain socioeconomic measures, for example ones relating to direct measures of

income, were not available for the cities of Glasgow and Manchester. In addition, I was restricted by the length of the time series for which data were collected within the Medical Officer of Health reports. In particular, it would have been preferable to have had a longer dataset for Manchester, starting prior to 1891, but these data were not available. The lack of individual level data for Glasgow and Manchester mean that my analysis is inevitably restricted to looking at small area differentials. The lack of cause of death data for the Nancy dataset has already been mentioned and reduced some of the possible analyses that it would have been desirable to undertake, such as linking cause of death of the breadwinner to prior accommodation changes or to subsequent deaths of other family members. It should also be noted that the general conclusion of this thesis is that socioeconomic differences were important in explaining differences in mortality and other health outcomes in the nineteenth and early twentieth centuries. As many of the measures used are proxies (e.g. rent or persons per room used as a proxy for income), it is not always possible to be sure how or why the associations existed, and caution should therefore be used when interpreting individual variables.

Possible avenues for future work on the Glasgow dataset would be to extend the analysis of mortality dynamics to other measures of mortality. It would also be useful to investigate which other cities collected data at a similar level of detail and length of time series, which would permit the extension of the analysis to other areas. Another possible area of interest would be to explore the impact of known open or green space on historical health and mortality.

Future work on the Nancy dataset could focus on extending the sample size, for example to increase the statistical power of the models. Work to extend the size of the Nancy sample would also be desirable because the individual-level data it contains allow the analysis of new questions that are typically not accessible to researchers interested in historical periods. Some of these questions can be answered using a dataset of the scale I have already collected, for example collaborative work is being undertaken on assortative mating (Stewart et al., 2024), but others require more data to analyse statistically. It would be interesting to undertake quantitative analysis of other possible alternative sources of income (e.g. taking in lodgers) that allow families to survive the loss

of the breadwinner with relatively little fall in rent paid. Another possible approach could be to seek other influences on the ability of the family to cope following the loss of the male head of household and to incorporate these with the existing dataset. There is also the potential to link the current dataset with, for example, military records, to provide an even richer resource (see e.g. Kesztenbaum, 2021). In the longer term, it may be possible to use the data from the Nancy annual censuses to explore further questions, with possible areas of interest being questions around income, occupation and fertility.

The creation of these unique datasets has enabled me to analyse historical health inequalities in new ways and to separate out the influences of different socioeconomic variables. I am able to show that the influence of some socioeconomic conditions on mortality lasted for forty or more years, while others appeared to be less long-lasting, possibly because policy interventions had acted to reduce their importance. When considering the influence of socioeconomic conditions on vaccination decisions in early twentieth century Glasgow, I found that the relationship between lower socioeconomic status and higher vaccination refusal or hesitancy was similar to that which exists today, suggesting the existence of embedded social attitudes over the long-term. My examination of bereaved families in Nancy examined a number of different influences on the age at death of the breadwinner and found that occupation was the most significant. I was also able to study the financial situation of the family in the immediate period post-bereavement which has rarely been possible with other datasets. The short- and long-term association of lower socioeconomic conditions with poorer health suggests that policies to reduce socioeconomic inequalities will have a positive impact on health outcomes. My findings add to the considerable literature on the importance of socioeconomic conditions for health inequalities.

Chapter 8 Appendices

8.1 Appendix 1 (Chapter 2)

8.1.1 Glasgow wards

Table 8-1. List or Glasgow municipal ward numbers and ward names as existed in 1903

Ward number	Ward name
1	Dalmarnock
2	Calton
3	Mile-End
4	Whitevale
5	Dennistoun
6	Springburn
7	Cowlairs
8	Townhead
9	Blackfriars
10	Exchange
11	Blythswood
12	Broomielaw
13	Anderston
14	Sandyford
15	Park
16	Cowcaddens
17	Woodside
18	Hutchesontown
19	Gorbals
20	Kingston
21	Govanhill
22	Langside
23	Pollokshields
24	Kelvinside
25	Maryhill

A map of the boundaries of the sanitary districts in 1902 and the wards in 1903 was provided in the Medical Officer of Health Report for 1903 and is included below to show how the two sets of boundaries related to each other (Figure 8-1).

Figure 8-1. Map showing both the ward and sanitary district boundaries, 1902-3
This map is reproduced from the Report of the Meical Officer of Health of Glasgow, 1903, (Russell 1903), courtesy of the Wellcome Trust.

8.1.2 Differences between crude death rate and age standardised mortality rate

Only one ward, Exchange, exhibits reasonably large differences between the crude death rate and the age standardised mortality rate in both 1901 and 1911 (Figure 8-2). Exchange is a ward in the central business district of the city with a small population. Consideration is given to excluding Exchange from the Glasgow analysis, in order to reduce the impact of using crude death rate rather than age-standardised mortality rate in statistical analyses, see Section 2.5.4.

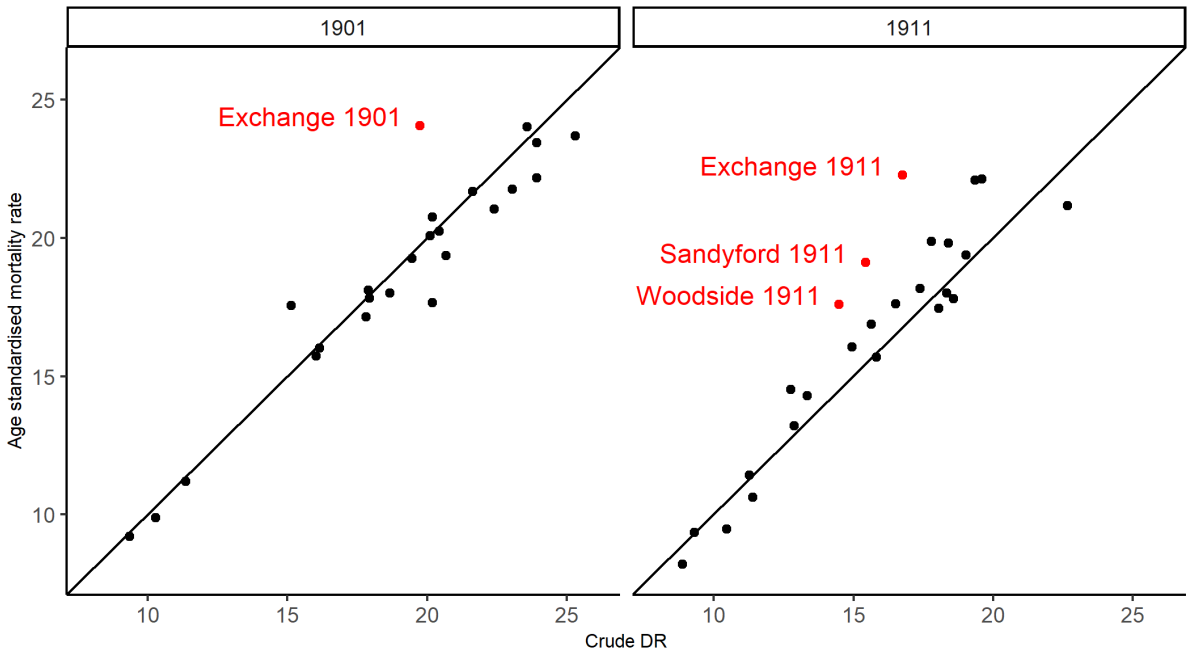


Figure 8-2. Scatterplot of crude DR against age standardised mortality rate, Glasgow
For 1901 and 1910. The black line indicates where points would be if the two values were equal. Wards where the two values vary by more than 3 per thousand population are shown in red.

8.1.3 Further issues with historical data

It is probable that in the years immediately following the introduction of the new registration acts adherence was not complete. In particular, the births and deaths of the very poor, particularly itinerant people, may not have been fully registered. However, as penalties could be issued for non-compliance the numbers involved are likely to be low. There were suspicions at the time of the underreporting of the births and deaths of infants who died before 21 days, the time limit provided in the act for the registration of births (Centre for the History of Medicine, 2024); however, no evidence is available of the extent to which this actually happened.

The requirement to include the cause of death provides much useful information, although it could not always be considered accurate, especially in the early years following the acts. For example, the doctor may not have seen the patient during the last illness, or might have avoided identifying certain diseases that might embarrass the family (Reid et al., 2015). In addition, some terms used were ambiguous or unclear, leading to the death being classified as due to ‘other causes’. Over time, the number of diseases in this category declined and more confidence can be placed in the accuracy of the records (Lee,

1991, p61). Even when the data were accurate for the time in which they recorded, they might not be accurate according to more recent understanding, for example, typhoid (caused by a water-born bacteria) and typhus (caused by bacteria from fleas or lice) were thought to be the same disease until the mid-1800s. Both diseases were placed in the same category in Scotland until 1865 (Reid et al., 2015). These limitations regarding cause of death do not apply to my study of mortality, as I do not use cause of death in my analysis, but it is something I have had to be aware of when constructing the dataset from which the current data are drawn.

8.1.4 Other variables collected for Glasgow

Other variables were collected for Glasgow but are not analysed in this thesis. For example, there are indications of the level of poverty of an area from the number of 'farmed-out' houses and houses let in lodgings, both of which were let for very short periods to people who couldn't afford or obtain a longer lease. Farmed out houses were of particular concern to the Medical Officer of Health, as the 'occupant falls short of the standard by which the caretaker or house-factor estimates the desirable tenant… The attraction to the occupant is that he need produce no evidence of former regularity in rent-paying; that it now may he paid in nightly doles of 10d., or 5.s. per week, for which also he has the use of certain domestic furnishings in their simplest form' (Chalmers, 1902a, p21). These data are available in the Medical Officer of Health reports at sanitary district or ward level for some years 1901-1914, but not thereafter.

Variables that reflected attitudes to risk were also recorded by the Medical Officer of Health at administrative area level, such as deaths in friendly societies (indicating whether the family had purchased burial insurance).

For the full list of variables collected, 1878-1937, see Table 8-2. Note that not all variables are available for all years.

Table 8-2. Data dictionary of variables included in the Glasgow dataset

VARIABLE NAME	EXPLANATION (unless obvious)
Population	
Under_1_perc_population	
Under_5_perc_population	

VARIABLE NAME	EXPLANATION (unless obvious)
Under_15_perc_population	
Under_5_population	
Acreage	
Persons_per_acre	
Inhabited_houses	
Inhabited_houses_per_acre	
Persons_per_house	
Persons_per_room	
Windowed_rooms_per_hse	Windowed rooms per house
Windowed_rooms_total	
Farmed_out_houses	Number of 'farmed out' houses. These were very basic accommodation let out on a short term basis.
Farmed_out_houses_inmates	Number of people living in 'farmed out' houses
Houses_let_in_lodgings	Number of 'farmed out' houses. These were very basic accommodation let out on a short term basis, similar to 'farmed out' houses.
Houses_let_in_lodgings_inmates	Number of people living in houses let in lodgings
Irish_born_perc	Percentage of the population born in Ireland
Births	
Birth_rate_1000	Birth rate per 1000 population
Illegitimate_births	
Illegitimate_births_percent	Illegitimate births as percent of all births
Deaths	
Death_rate_1000	Death rate per 1000 population
Age_stand_DR	Age standardised death rate per 1000 population
Death_rate_no_WW	Death rate per 1000 population excluding World War years
Death_rate_Inf_Dis_1000	Death rate from infectious diseases per 1000 population
Deaths_under_1_year_thou_births	Deaths under year per 1000 births
Deaths_under_1_year	
Deaths_1_5_yr	Deaths from 1 year to under 5 years
Deaths_under_5_year	
Deaths_5_20_yr	Deaths from 5 year to under 20 years
Deaths_5_15_yr	As above, see actual ages used
Deaths_15_25_yr	As above, see actual ages used
Deaths_15_20_yr	As above, see actual ages used
Deaths_20_25_yr	As above, see actual ages used
Deaths_25_45_yr	As above, see actual ages used
Deaths_20_60_yr	As above, see actual ages used
Deaths_25_60_yr	As above, see actual ages used
Deaths_45_65_yr	As above, see actual ages used
Deaths_60_and_above	

VARIABLE NAME	EXPLANATION (unless obvious)
Deaths_65_and_above	
Cons_Obj_to_Vacc	Conscientous objection to smallpox vaccination
COV_Proportion_Survived	Conscientous objection to smallpox vaccination as a proportion of children who survived to 1 year
Deaths_in_Friendly_Soc	Deaths where the person was a member of a Friendly Society (a type of insurance society, often concerned specifically with the costs of burial)
Deaths_violence	
Deaths_Prem_Birth	Deaths due to premature birth, as given in MOH report
Deaths_Measles	
Deaths_Whooping_cough	
Deaths_Smallpox	
Deaths_Scarlet_fever	
Deaths_Cerebro_Spinal_fever	
Deaths_Phthisis	
Deaths_Diphtheria	
Deaths_Acute_lung_disease	
Deaths_Pneumonia	
Deaths_Bronchitis	
Deaths_Diarrhoea	
Deaths_Enteric_fever	
Deaths_Puerperal_fever	
Deaths_Typhus	
Deaths_Influenza	
DR_Prem_Birth	Death rate from premature birth per 1000 population.
DR_Measles_1000	As above but for disease as listed
DR_Whooping_cough_1000	As above but for disease as listed
DR_Smallpox_1000	As above but for disease as listed
DR_Scarlet_fever_1000	As above but for disease as listed
DR_Cerebro_Spinal_fever_1000	As above but for disease as listed
DR_Phthisis_1000	As above but for disease as listed
DR_Diphtheria_1000	As above but for disease as listed
DR_Acute_lung_disease_1000	As above but for disease as listed
DR_Pneumonia_1000	As above but for disease as listed
DR_Bronchitis_1000	As above but for disease as listed
DR_Diarrhoea_1000	As above but for disease as listed
DR_Enteric_fever_1000	As above but for disease as listed
DR_Typhus_1000	As above but for disease as listed
DR_Influenza_1000	As above but for disease as listed
Cases_Measles	Cases of measles as listed in MOH report, including both home and hospital
Cases_Whooping_cough	As above but for disease as listed

VARIABLE NAME	EXPLANATION (unless obvious)
Cases_Smallpox	As above but for disease as listed
Cases_Scarlet_fever	As above but for disease as listed
Cases_Cerebro_Spinal_fever	As above but for disease as listed
Cases_Diphtheria	As above but for disease as listed
Cases_Enteric_fever	As above but for disease as listed
Cases_Puerperal_fever	As above but for disease as listed
Cases_Typhus	As above but for disease as listed

MOH refers to Medical Officer of Health.

8.1.5 Apportioning sanitary districts to wards

The following information was used to apportion sanitary district variables to wards: (i) the mapped boundaries of the different geographies (in the form of shapefiles); (ii) the density of built-up areas (from GeoTIFFs[41]); and (iii) the proportion of premises that were non-residential. For example, the initial calculation of the population to be reallocated was based on the area of the sanitary district which became part of the ward, as a proportion of the total area of the sanitary district. This value was then weighted by the density of buildings in the area, with a higher density providing a higher population figure. Finally, a reduction to the figure was made based on the proportion of non-residential buildings that were known to be present. The process we used to carry out the apportionment from sanitary districts to wards is described in full in the joint paper by Angelopoulos, Stewart and Mancy (Angelopoulos et al., 2023). An analogous process was used when mapping the new wards back to the pre-1921 wards. By converting the data in this way, three sets of data were created: i) an interrupted data series for the 21 mostly central wards for 1878-85 and 1891-1937[42]; ii) a continuous annual time series for 25 wards from 1891 to 1937; and iii) a continuous annual time series for 37 wards from 1912 to 1937 (only used in Chapter 4)

[41] A GEOTIFF embeds geo-spatial metadata from, e.g., digitised maps, so that the georeferencing information is available for use by other applications.

[42] Parts of Govanhill, Cowlairs and Springburn wards were within the pre-1891 boundaries and parts were outwith these boundaries. This change appears to have no impact on variables recorded for Cowlairs and Springburn, but may impact on the early observations in Govanhill. All three wards have been retained in the longer dataset, but this issue is noted.

8.1.6 Glasgow death rates by ward

Figure 8-3 shows changes in the death rate over the period 1891-1937 for the 25 municipal wards which existed for these years, showing that death rates fell over the period for most wards.

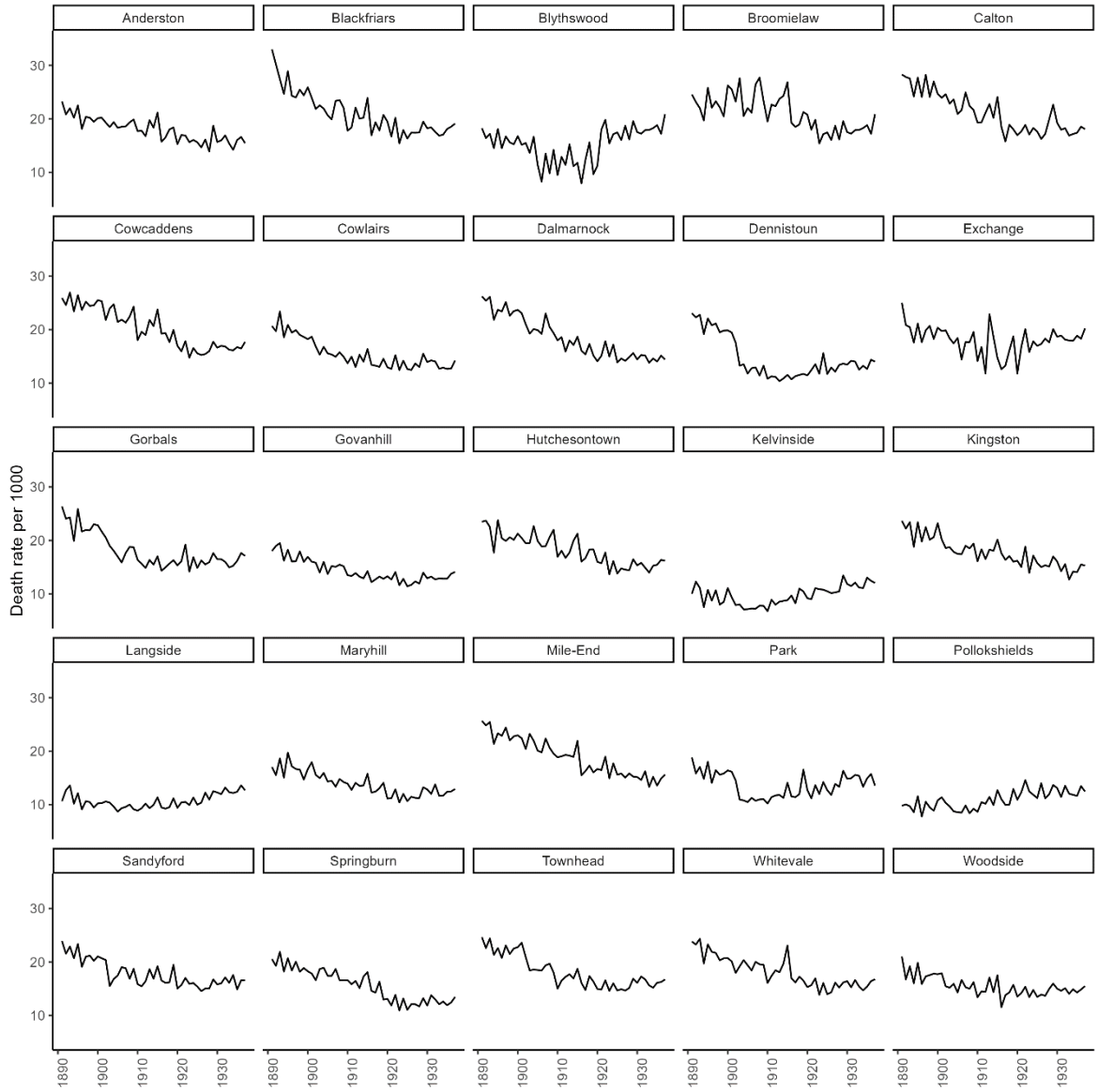


Figure 8-3. Crude death rate for 25 Glasgow wards, 1891-1937

8.1.7 Manchester death rates by statistical division

Figure 8-4 shows the change in the death rate over the period 1891-1924 for the 18 statistical divisions of Manchester which existed for all years, showing that death rates fell over the period for most statistical divisions.

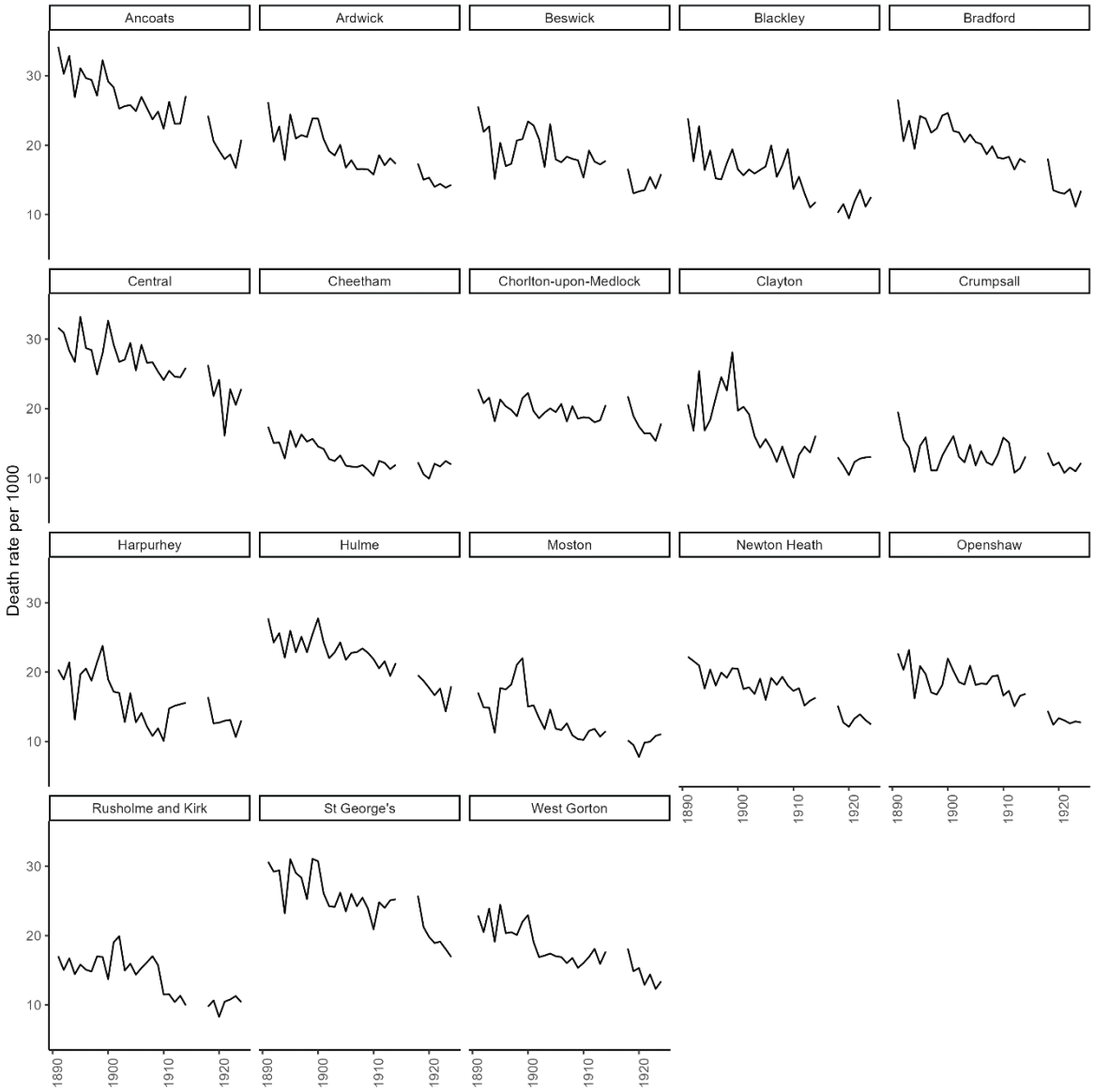


Figure 8-4. Crude death rate for 18 Manchester statistical divisions, 1891-1924
Data were not recorded for three years during the First World War (1915-17).

8.1.8 Glasgow regressions excluding Exchange ward

Due to the concerns about the differences between the crude death rate and the age standardised mortality rate in Exchange ward, the regressions in Equation [1] were re-run for 24 Glasgow wards, excluding Exchange. The output was very similar to that for 25 wards, so any issues about Exchange being a possible outlier do not impact on the analysis; see Table 8-3.

Table 8-3. Socioeconomic conditions and the mortality penalty for Glasgow, excluding Exchange.

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-368**	-264***	-.27**	-57***
	(102)	(41.5)	(66.8)	(69.5)
Persons per room 1891	157**			142***
	(50.6)			(29.5)
Population density 1891		2.18***		1.40***
		(0.39)		(0.34)
Percent illegitimate births 1898			25.9*	16.9*
			(9.53)	(6.11)
R2	0.304	0.586	0.251	0.815
Number of observations	24	24	24	24

Notes: Estimates shown for the specification in equation [1]. Least squares estimate, with ordinary standard errors shown in parentheses *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

8.1.9 Glasgow regressions with ordinary standard errors

The models using Equation [1] were also run with ordinary standard errors. The influence of persons per room and population density remains much the same, especially in Model 4, but the statistical significance of percent illegitimate births increases slightly; see Table 8-4 and Table 8-5.

Table 8-4. Socioeconomic conditions and the mortality penalty, Glasgow, ordinary standard errors

	(1)	(2)	(3)	(4)
(Intercept)	-348.06**	-256.60***	-210.98**	-580.58***
	(100.26)	(41.14)	(62.43)	(67.30)
Persons per room 1891	149.02**			142.25***
	(49.97)			(28.88)
Population density 1891		2.15***		1.356***
		(0.39)		(0.32)
Percent illegitimate births 1898			22.75*	18.0**
			(8.46)	(5.14)
R2	0.279	0.568	0.239	0.815
Number of observations	25	25	25	25

Notes: Estimates shown for the specification in equation [1]. Least squares estimate, with ordinary standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Table 8-5. Socioeconomic conditions and the average DR 1933-37 Glasgow, ordinary standard errors

	(1)	(2)	(3)	(4)
(Intercept)	14.96***	12.40***	11.57***	10.36***
	(1.69)	(0.63)	(0.63)	(1.01)
Persons per room 1891	0.06			0.177
	(0.84)			(0.431)
Population density 1891		0.029***		0.018***
		(0.006)		(0.005)
Percent illegitimate births 1898			0.526***	0.406***
			(0.085)	(0.077)
R2	0.000	0.510	0.624	0.799
Number of observations	25	25	25	25

Notes: Estimates shown for the specification in equation [1]. Least squares estimate, with ordinary standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

8.1.10 Manchester regressions with ordinary standard errors

The models using Equation [1] for the Manchester data were also re-run with ordinary standard errors. The statistical significance of the results increases as compared with Bell McCaffrey standard errors (see Table 8-6 and Table 8-7).

Table 8-6. Socioeconomic conditions and the mortality penalty, Manchester, ordinary standard errors

	(1)	(2)	(3)
(Intercept)	-147.28**	-157.32*	-219.99***
	(38.18)	(59.89)	(45.34)
Population density 1891	2.35***		1.98**
	(0.52)		(0.49)
Percent illegitimate births 1891		40.71*	26.34*
		(14.69)	(11.05)
R2	0.557	0.324	0.679
Number of observations	18	18	18

Notes: Estimates shown for the specification in equation [1]. Least squares estimate, with standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Table 8-7. Socioeconomic conditions and the average DR 1920-24, Manchester, ordinary standard errors

	Model 1	Model 2	Model 3
(Intercept)	11.227***	10.095***	8.910***
	(0.869)	(1.111)	(0.823)
Population density 1891	0.049***		0.037***
	(0.012)		(0.009)
Proportion illegitimate births 1891		111.067***	83.910***
		(27.246)	(20.040)
R2	0.516	0.509	0.777
Number of observations	18	18	18

Notes: Estimates shown for the specification in equation [1]. Least squares estimate, with ordinary standard errors shown in parentheses. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.1; p-values are based on two-sided t-tests of statistical significance of the coefficient.

8.2 Appendix 2 (Chapter 3)

8.2.1 The 18 Manchester statistical divisions

Attempts were made to fit a logistic function to mortality data for all 18 Manchester statistical divisions. Due to the short time series, this function is not a good fit for the data, see Figure 8-5. It is not possible to calculate an inflection year for most plots.

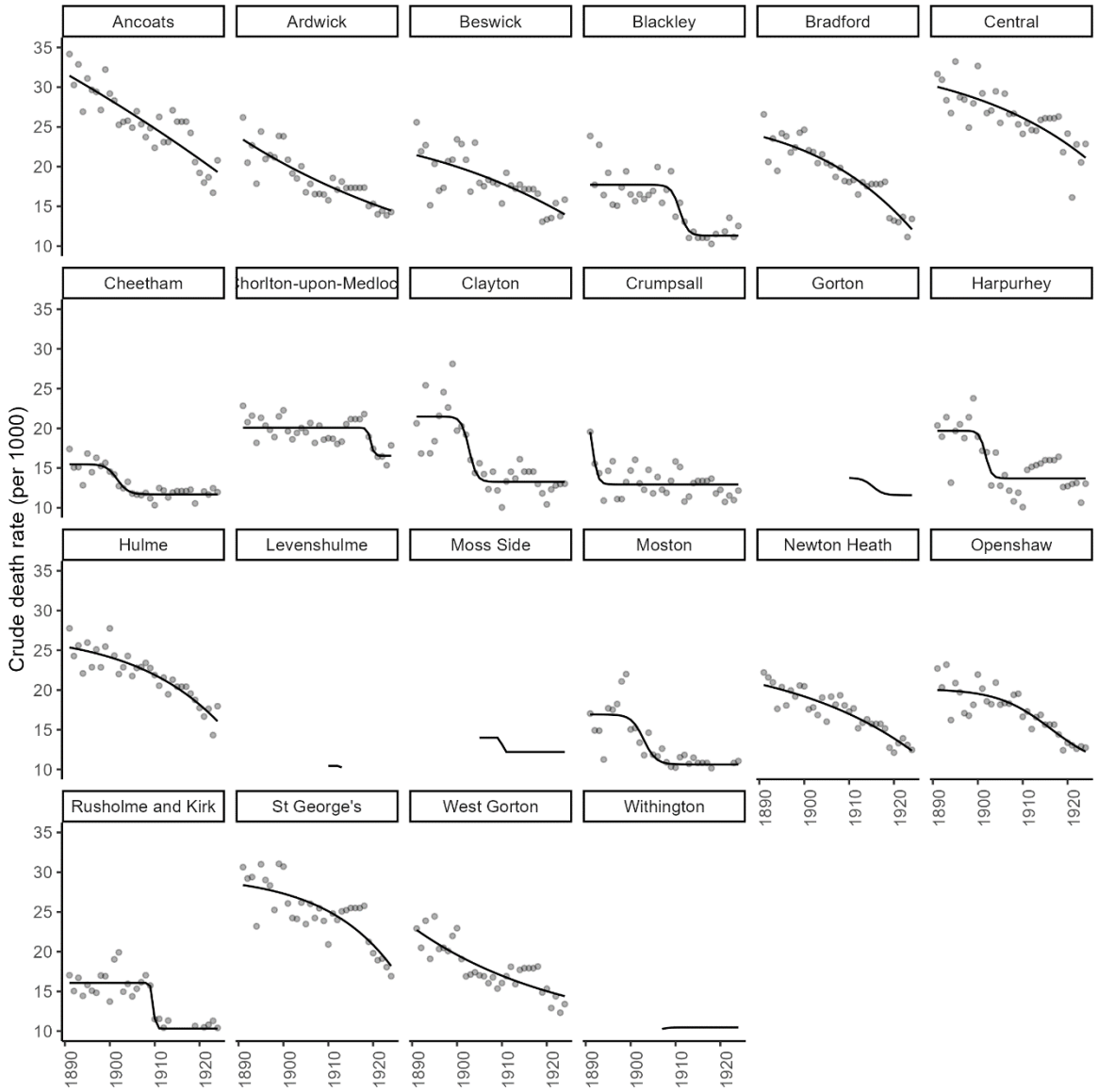


Figure 8-5. Death rates for 18 Manchester statistical division, 1891-1924.
Observed crude death rate (grey dots) and fitted 4-parameter logistic trend death rate (black line).

8.2.2 Glasgow, 25 wards, short time series

Attempts were made to fit a logistic function to mortality data for all the 25 Glasgow wards for which I have data from 1891-1937. Due to the short time series, this function is not a good fit for the data and it is not possible to calculate an inflection year for most plots, see Figure 8-6.

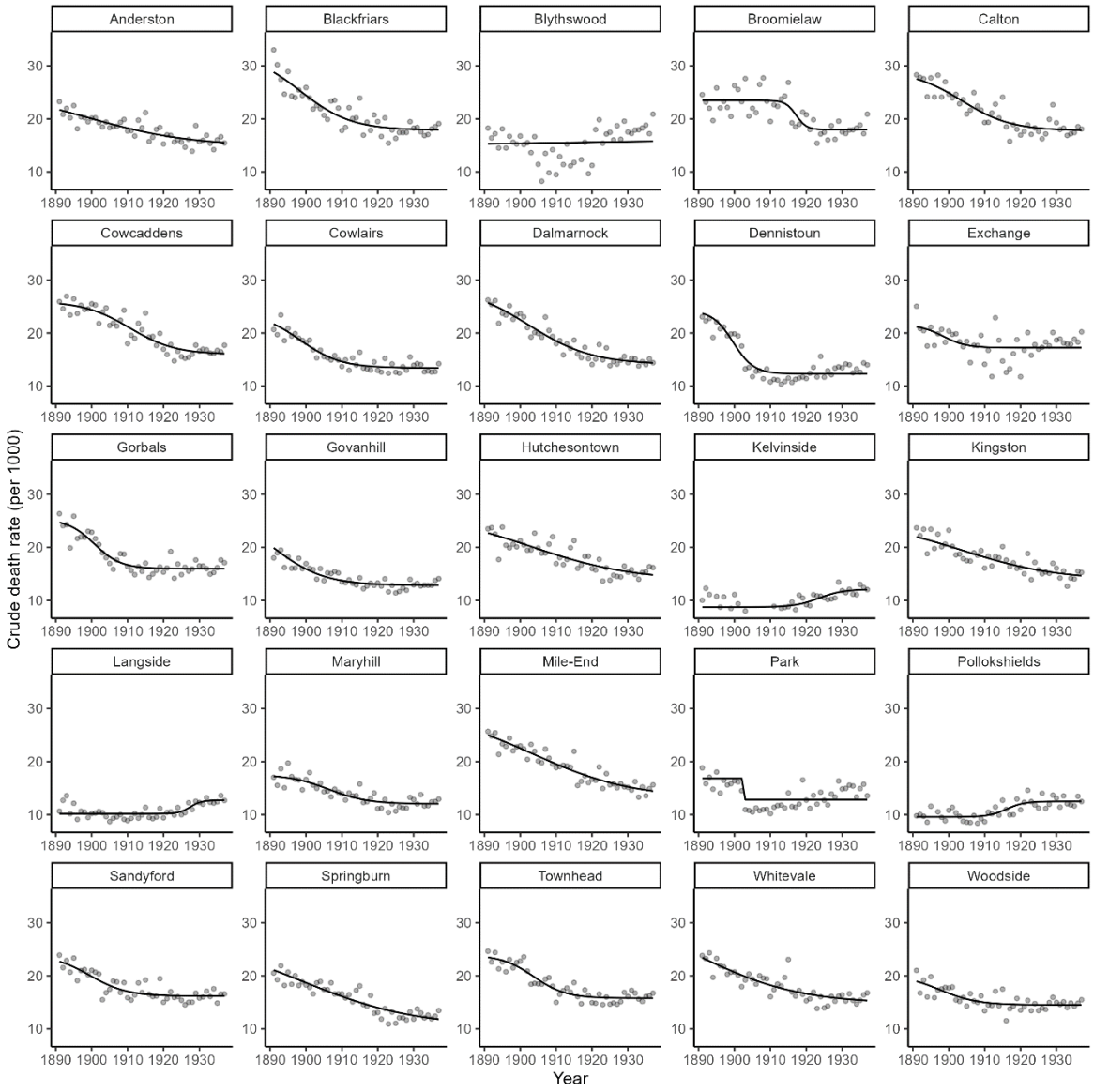


Figure 8-6. Death rates for 25 Glasgow wards, 1891-1937
Observed crude death rate (grey dots) and fitted 4-parameter logistic trend death rate (black line).

8.2.3 Issue with Manchester data for 1920 and 1921

Manchester's Medical Officer of Health suggested in 1921 that the population figures for 1920 were almost certainly incorrect, as the overall population of the city was revised downwards in 1921, presumably following that year's census. He

also expressed concerns that the populations of the statistical divisions in 1921 ‘may be doubted’ (Niven, 1922, p3). In fact, apart from Central division, the populations of divisions for 1921 are very much in line with subsequent years, so the main issue seems to be the large fall in population between 1920 and 1921. This fall is not spread equally over the statistical divisions, and therefore does not impact equally upon them. In particular, one of the highest mortality divisions, Central, appears to have a 40% increase in population in 1921 which results in a fall in the death rate from 24.2 in 1920 to 16.1 in 1921. The Central population figures are, however, revised again in 1922 so that the death rate in that year rises again, this time to 22.8. It appears, therefore, that 1921 should be considered as anomalous for Central, but that subsequent years are correct. Withington and Moston, which were two of the lowest death rate wards in 1920, both have their populations revised downwards in 1921 leading to an increase in the death rate, suggesting that the 1920 death rates should be higher. The populations for these two areas do not change much for the subsequent years so the 1921 death rates are probably correct.

There were also a number of boundary changes in 1921 (Niven, 1922). Crumpsall was enlarged, taking in an area that had previously been part of Blackley and also gaining an area that had previously been outside the city boundaries. Withington was also enlarged, taking in an area that had previously been outside the city boundaries. These changes may have contributed to the difference in the death rates of these divisions between 1920 and 1921, although it is hard to be sure how much of the change is due to the reallocation of population due to boundary changes and how much is due to revised population figures. Due to the issues discussed here, mortality data for some Manchester statistical divisions in 1920 and/or 1921 should be treated with caution.

8.2.4 Glasgow years ahead behind 25 wards

Years ahead and behind plots were created for all 25 Glasgow wards, see Figure 8-7.

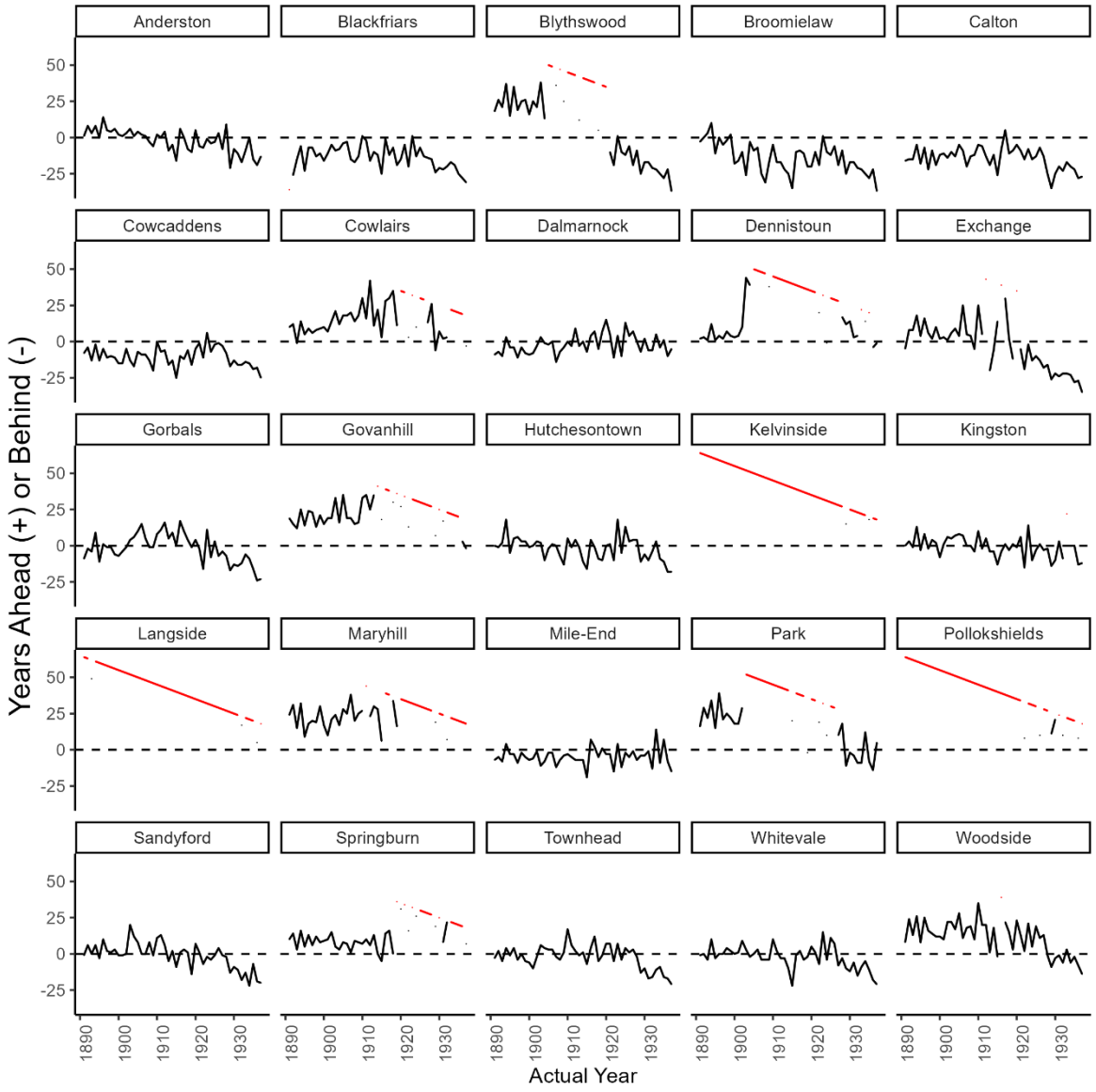


Figure 8-7. Plot of years ahead or behind the city average death rate 1855-1955 for 25 Glasgow wards, 1891-1937
Black indicates a true years ahead or behind position and red indicates estimated years ahead or behind compared to the start or end of the city data series (i.e. a minimum number). Zero is marked by a dashed line. Values above zero show the ward was ahead of the city average and values below show it was behind.

8.2.5 Manchester years ahead behind 18 statistical divisions

Years ahead and behind plots were created for all 18 Manchester statistical divisions, see Figure 8-8.

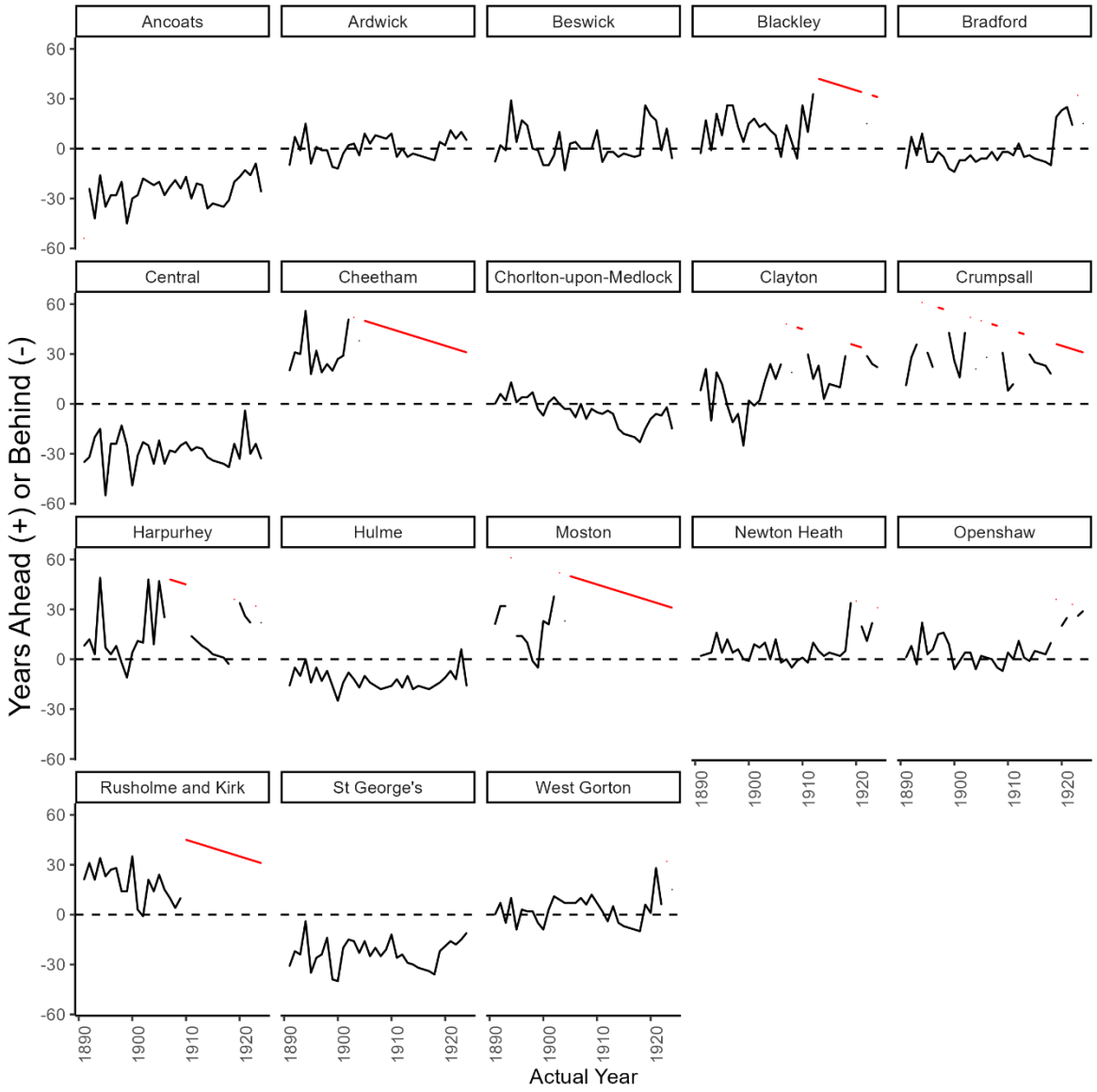


Figure 8-8. Plot of years ahead or behind the city average death rate 1837-1955 for all 18 statistical divisions, Manchester 1891-1924
Black indicates a true years ahead or behind position compared to the start or end of the city data series and red indicates estimated years ahead or behind (i.e. a minimum number). Zero is marked by a dashed line. Values above zero show the division was ahead of the city and values below show it was behind.

8.3 Appendix 3 (Chapter 4)

8.3.1 Correlation matrix for 1901

A correlation matrix was created for the socioeconomic variable for the Glasgow wards for 1901, see Table 8-8. Correlation values are not high, with the largest being between Persons per room and Percent Irish born, which is 0.541.

Table 8-8. Correlation matrix 25 Glasgow wards

	Persons per acre 1901	Persons per room 1901	Perc Irish Born 1901
Persons per acre 1901	1		
Persons per room 1901	0.444	1	
Perc Irish Born 1901	0.187	0.541	1

Includes the socioeconomic variables used in specifications [3]-[5].

8.3.2 Output from non-linear model

This non-linear model is similar to that specified in our earlier paper (Angelopoulos et al., 2023). Denoting by x the vector containing the explanatory variables in [3], [4] or [5] (including the constant term), and by β the associated vector of parameters, the conditional mean in the fractional regression context is given by

$$E(y|x) = \exp(x\beta) / [1 + \exp(x\beta)] . \qquad [8], [9], [10]$$

Quasi-maximum likelihood (QMLE) is used to estimate the parameters, using robust standard errors which allow for clustering of the error term by ward. Table 8-9 shows the output from this model, with high levels of statistical significance, as was seen with the linear models.

Table 8-9. Coefficient estimates of non-linear models of vaccine refusal rate in wards of Glasgow, 1907-1913

	(4)	(5)	(6)
(Intercept)	-2.54e+00***	-2.17e+00***	-2.65e+00***
	(1.92e-01)	(2.91e-01)	(2.17e-01)
Population density 1901	-7.42e-03***	-4.48e-03***	-4.49e-03***
	(1.59e-03)	(6.62e-04)	(6.74e-04)
Year Numeric	1.41e-01***	5.93e-02	1.66e-01***
	(3.33e-02)	(6.02e-02)	(4.01e-02)
Persons per room 1901	4.94e-01***	1.49e-01	4.94e-01***
	(8.23e-02)	(1.63e-01)	(8.32e-02)
Perc Irish Born 1901	-4.68e-02***	-4.65e-02***	-6.62e-02**
	(1.06e-02)	(1.05e-02)	(2.34e-02)
Population density 1901 × Year Numeric	6.40e-04*		
	(3.13e-04)		
Persons per room 1901 × Year Numeric		7.61e-02*	
		(3.13e-02)	
Perc Irish Born 1901 × Year Numeric			4.25e-03
			(4.51e-03)

Notes: Fractional regression (QMLE) estimation (for non-linear specification in equations [8], [9] and [10]). Robust standard errors clustered at the ward-level are shown in parentheses under the estimated coefficients. The dependent variable in all models is the vaccine refusal rate. Number of observations: 175 (25 wards); *** p < 0.001; ** p < 0.01; * p < 0.05; p-values are based on two-sided t-tests of statistical significance of the coefficient.

8.4 Appendix 4 (Chapter 5)

8.4.1 Data available in the Nancy census

Data provided in the Nancy censuses in the 1890s included: census number, address, name of owner, name of renter, names of other residents, place of birth of residents, date of birth and age of residents, occupation/relationship to head of household (all left-hand page); additional right of residence information (right-hand page), see Figure 8-9. In addition, information relating to the property was written above the property entry showing: location (floor and whether front or rear), number of rooms, and rent. The presence of a kitchen or toilet *cabinet* is also sometimes noted. If a family had moved, their previous or following census number (and *Section*, if different) was also noted.

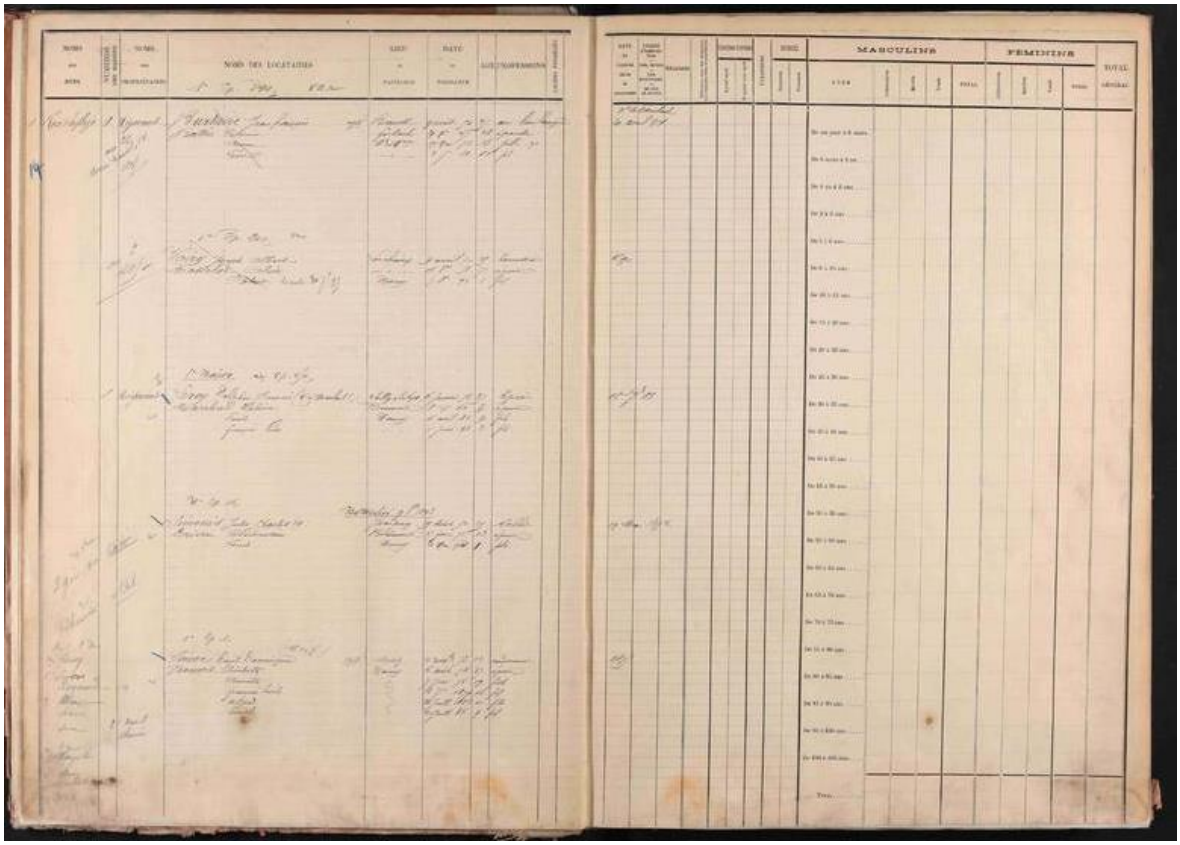


Figure 8-9. Example of a census entry from the Nancy *recensement,* showing both pages in full
Example from 1895, *Section* 1, Volume 1. Original held in the *Archives Nationales de Nancy*. Copy courtesy of the *Archives Nationales de Nancy*.

8.4.2 HISCLASS classifications

The HISCLASS system (Van Leeuwen and Maas, 2011) was used to classify all occupations. The full classifications and examples from the Nancy dataset are given in Table 8-10.

Table 8-10. HISCLASS classification table

Classification *	General Description*	Number in head of household sample	Manual/ Non-manual*	Label**	Examples from Nancy dataset
1	Higher managers	5 deceased	Non-manual	Owner, Proprietor	*Proprietaire, Rentier*
					Sans profession
2	Higher professionals	11 deceased	Non-manual	Accountant, General	*Comptable*
				Bridge Construction Engineer	*Pontonnier*
				Building Construction Engineer	*Entrepreneur de batiments*
				Teacher in History, Philosophy, Sociology and Related Social Sciences (Third Level)	*Professeur au lycée*
3	Lower managers	8 deceased	Non-manual	Non-Commissioned Officer	*Conducteurs des Ponts et chausées, adjoint du Génis territorial*
				Non-Commissioned Officer	*Lieutenant*
4	Lower professionals and clerical and sales personnel	26 deceased	Non-manual	Working Proprietor (café, bar and snack bar)	*Cafetier*
				Working Proprietor (Retail Trade)	*Marchand de bouchons*
				Mechanical Engineering Technician, General	*Mécanicien ajusteur*
				Working Proprietor (Catering, Lodging or Leisure Services)	*Cabaratier*
				Working Proprietor (café, bar and snack bar)	*Débitant*
5	Lower clerical and sales personnel	12 deceased	Non-manual	Bank Clerk	*Employé de banque*
				Other Building Caretakers	*Concierge*
				Other Clerks	*Employé de bureau*
				Retail Trade Salesperson	*Representant de commerce*
				Other Sales Worker	*Gérant du debit*
6	Foremen	1 deceased	Manual	Supervisor and General Foreman (Construction Work)	*Chef d'atelier*
				Supervisor and General Foreman (Production of Textiles and Clothing Manufacturing)	*Dirigeant d'atelier*
7	Medium skilled workers	67 deceased	Manual	Blacksmith, General	*Forgeron*
				Baker, General	*Boulanger*
				Cabinetmaker	*Ebéniste*

Classification *	General Description*	Number in head of household sample	Manual/ Non-manual*	Label**	Examples from Nancy dataset
				Plumber, General	*Plombier*
				Tool and Die Maker	*Tailleur de limes*
				Dressmaker	*Couturiere*
				Shoe-maker, General	*Cordonnier*
8	Farmers and fishermen	1 deceased	Manual	General Farmer	*Fermetier*
				General Farmer	*Fruitiere*
9	Lower skilled workers	17 deceased	Manual	Baker's assistant	*Garcon boulanger*
				Basket Maker	*Vannier*
				Charcoal Burner	*Charbonniere*
				Other Cigar Makers	*Cigariere*
				Women's or Men's Hairdresser	*Coiffeur*
				Launderer, General	*Lingere*
10	Lower skilled farm workers	None	Manual		
11	Unskilled workers	14 deceased	Manual	Day-Labourer	*Journalier*
				Excavator (Hand Tools)	*Terrassier*
				Labourer	*Manoeuvre*
12	Unskilled farm workers	1 deceased	Manual	Gardener	*Jardinier*
				Farmworker, General	*Chevrier*

*HISCLASS summary (Van Leeuwen and Maas, 2011, p57)

**HISCLASS label, which is matched to classification (Van Leeuwen and Maas, 2011, p131-80)

8.4.3 Correlation matrix for Nancy variables

A correlation matrix was created for a number of socioeconomic and family variables for the Nancy dataset, see Figure 8-10. There were no very strong correlations between Age at Death of the head of household and the other variables.

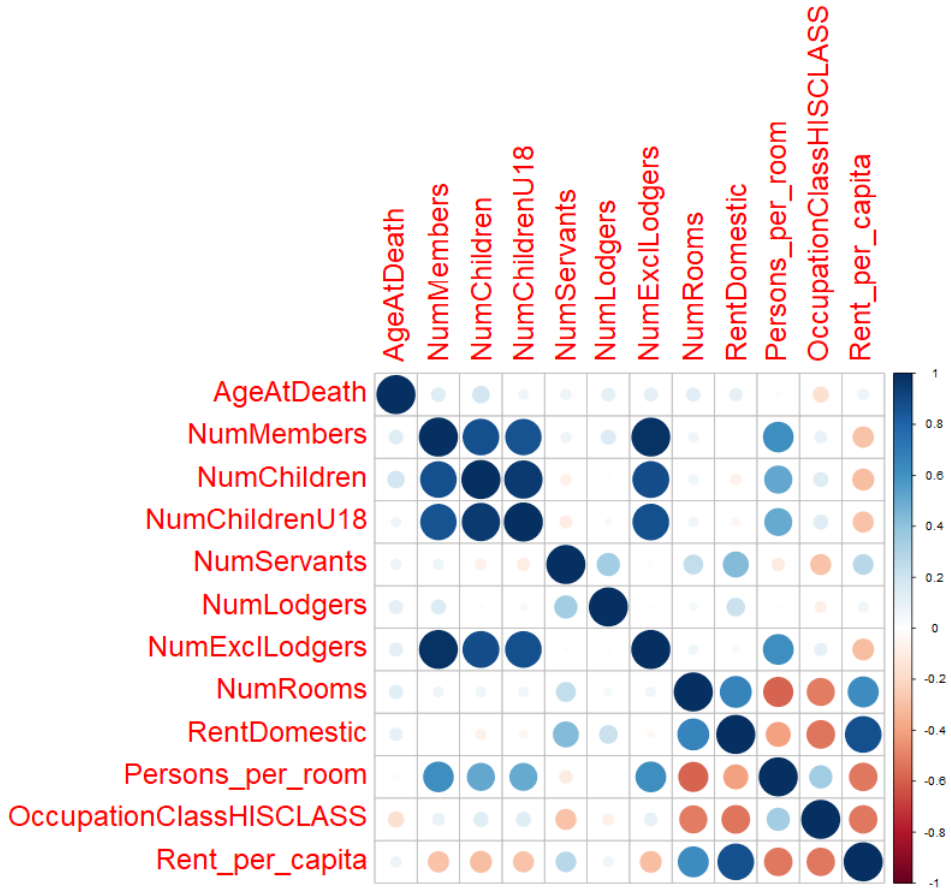


Figure 8-10. Correlation matrix of a number of variables and age at death of the head of household
Pink indicates a negative correlation and blue a positive correlation. A larger circle and a darker colour indicates a stronger correlation.

8.4.4 Robustness checks for age at death, Nancy

The regressions for the results are shown in Table 5-4 and Table 5-5 were re-run with robust standard errors, not clustered, with the results shown in Table 8-11 and Table 8-12. The results remain statistically significant, although the level of significance reduces.

Table 8-11. Socioeconomic and other variables and the age at death of the breadwinner, without clustering

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	42.938***	38.907***	42.051***	41.605***	43.084***	39.661***
	(1.189)	(0.944)	(1.288)	(1.573)	(2.519)	(2.526)
Low occupational status	-3.696*		-4.210*	-3.558*	-3.422.	
	(1.629)		(1.642)	(1.780)	(1.835)	
Medium occupational status	-3.015*		-3.357*	-2.976*	-2.593.	0.829
	(1.305)		(1.361)	(1.429)	(1.463)	(1.260)
High occupational status						3.422.
						(1.835)
Rent		0.002.		0.001	0.002	0.002
		(0.001)		(0.001)	(0.002)	(0.002)
Persons per room		0.204		-0.155	-0.051	-0.051
		(0.216)		(0.282)	(0.301)	(0.301)
Number of children			0.645**	0.727**	0.693*	0.693*
			(0.213)	(0.259)	(0.291)	(0.291)
Spring-Summer					-0.548	-0.548
					(0.967)	(0.967)
Section 1					-0.833	-0.833
					(2.114)	(2.114)
Section 3					-3.085	-3.085
					(2.157)	(2.157)
Section 4					-3.379	-3.379
					(2.242)	(2.242)
Section 5					-0.464	-0.464
					(2.310)	(2.310)
Section 6					-3.129	-3.129
					(2.375)	(2.375)
Section 7					-5.425*	-5.425*
					(2.591)	(2.591)
Section 8					-1.201	-1.201
					(2.100)	(2.100)
R2	0.029	0.016	0.072	0.078	0.132	0.132
Number of observations	161	161	161	161	161	161

Notes: Estimates shown for the specification in equation [6]. Comparing occupational status levels. Least squares estimate with robust standard errors. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Table 8-12. Socioeconomic and other variables and the age at death of the breadwinner, without clustering

	Model 1	Model 3	Model 4	Model 5
(Intercept)	41.274***	40.241***	40.251***	41.854***
	(0.690)	(0.751)	(1.101)	(2.424)
Manual occupations	-1.911*	-2.337*	-2.120.	-1.891
	(0.912)	(0.922)	(1.132)	(1.181)
Number of children		0.681**	0.737**	0.692*
		(0.214)	(0.257)	(0.288)
Rent			0.000	0.002
			(0.001)	(0.002)
Persons per room			-0.122	-0.001
			(0.294)	(0.311)
Spring-Summer				-0.713
				(0.968)
Section 1				-0.944
				(2.204)
Section 3				-2.810
				(2.264)
Section 4				-3.398
				(2.276)
Section 5				-0.692
				(2.445)
Section 6				-3.249
				(2.461)
Section 7				-5.721*
				(2.614)
Section 8				-1.110
				(2.195)
R2	0.026	0.074	0.075	0.128
Number of observations	161	161	161	161

Notes: Estimates shown for the specification in equation [6]. Compares manual and non-manual occupational status levels. Least squares estimate with robust standard errors. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The regressions for the results are shown in Table 5-4 were re-run for the full sample of 164 records and the output is shown in Table 8-13.

Table 8-13. Socioeconomic conditions and the age at death, Nancy, 1895-97, with the full sample of 164 records

	(1)	(2)	(3)	(4)	(5)	(6)
(Intercept)	42.938***	38.994***	42.123***	41.510***	42.103***	39.189***
	(0.732)	(0.919)	(0.670)	(1.050)	(0.490)	(0.849)
Low occupational status	-3.357***		-3.766***	-3.021***	-2.914**	
	(0.772)		(0.835)	(0.763)	(0.945)	
Medium occupational status	-2.989***		-3.293***	-2.863***	-2.441***	0.473
	(0.697)		(0.682)	(0.567)	(0.533)	(0.661)
High occupational status						2.914**
						(0.945)
Rent		0.002*		0.001	0.002.	0.002.
		(0.001)		(0.001)	(0.001)	(0.001)
Persons per room		0.191		-0.147	-0.031	-0.031
		(0.245)		(0.306)	(0.291)	(0.291)
Number of children			0.593***	0.676**	0.640*	0.640*
			(0.169)	(0.249)	(0.274)	(0.274)
Spring-Summer					-0.529	-0.529
					(0.982)	(0.982)
Section 1					0.712	0.712
					(0.549)	(0.549)
Section 3					-2.332***	-2.332***
					(0.169)	(0.169)
Section 4					-2.659***	-2.659***
					(0.485)	(0.485)
Section 5					0.231	0.231
					(0.292)	(0.292)
Section 6					-2.171***	-2.171***
					(0.559)	(0.559)
Section 7					-4.712***	-4.712***
					(0.529)	(0.529)
Section 8					-0.246*	-0.246*
					(0.111)	(0.111)
R2	0.026	0.016	0.063	0.071	0.127	0.127
Number of observations	164	164	164	164	164	164

Notes: Estimates shown for the specification in equation [6]. Least squares estimate with robust standard errors. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Variance inflation factors were calculated for each independent variable in [6], to test for collinearity. The results are shown in Figure 8-11 and indicate that there are no issues with multicollinearity, with all values being less than 2.

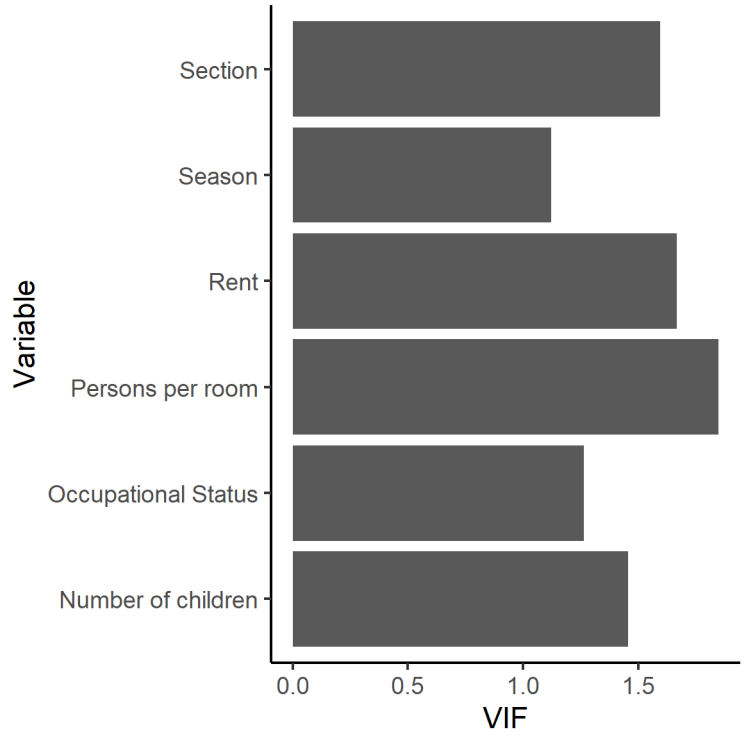


Figure 8-11. Variance inflation factor (VIF) calculated for each of the independent variables in equation [6]

8.5 Appendix 5 (Chapter 6)

8.5.1 Method for selecting controls, Nancy dataset

1. Find families in the same neighbourhood as deceased family/families who were paying the same or similar rent. If the rent was low, this was usually within 10%. For high rental properties (over 800f), where there were fewer options, the rental might vary by as much as 50%, but was always 'high' (i.e. over 800f).

2. From the families in 1., select those who had the same number of rooms to the family/families of the deceased.

3. From the families in 2., select those who had a similar number of children of similar ages to the family/families of the deceased. Ideally, the number of children within the family should not differ by more than 1, although it was not always possible to adhere to these criteria.

8.5.2 Alternative test of sample attrition

This analysis complements that undertaken in Table 6-1 in the main text. The comparison is made between the original sample of 161 and the sample after the first year/move of 135. Probit models were run to test which variables, if any, were associated with a record being lost to the sample after one move/year. This comparison is made between the original sample of 161 and the sample after the first year/move of 135. Three models were run, the first including persons per room, rent, age of wife, number of children, occupational status of deceased breadwinner and the type of accommodation occupied, all of which might be expected to vary between the two groups. Each type of accommodation is listed separately. The second model replaced type of accommodation with a binary measure for whether the household lived in a *garni* or not. The third was as for the second but replaced occupational status with a manual/non-manual binary measure (Table 8-14). This output suggests that the number of children in the family, and whether or not they lived in a garni, is statistically related to sample attrition. On the other hand, living in a *baraque* was positively associated with being retained in the sample.

Table 8-14. Probability of a household being lost to the sample

	(1)	(2)	(3)
(Intercept)	1.849*	1.726*	2.546*
	(0.900)	(0.863)	(1.076)
Persons per room	0.003	0.015	0.073
	(0.084)	(0.079)	(0.077)
Rent	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
Age of wife	-0.030	-0.030	-0.039.
	(0.021)	(0.021)	(0.022)
Number of Children	0.215.	0.215.	0.216.
	(0.124)	(0.125)	(0.120)
Medium occupational status	0.185	0.210	
	(0.360)	(0.355)	
High occupational status	-0.223	-0.254	
	(0.532)	(0.520)	
Manual occupation			-0.552
			(0.367)
Apartment	-0.138		
	(0.427)		
House	-0.357		
	(0.812)		
Baraque	4.007***		
	(0.439)		
Garni	-1.913*		
	(0.771)		
Garni (Y/N)		-1.846**	-2.074***
		(0.678)	(0.607)

. p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Notes: Coefficient estimates for the impact of other variables on the probability of being lost from the sample after one move or year. Occupation is of deceased head of household. Probit model with standard errors shown in brackets. Sample size = 161 households.

8.5.3 Robustness checks and extensions, effect of death of breadwinner

In the main text, I show that living in *Section* 2, which is probably the highest rent area of the city, rather than having originally lived in any of the other *sections* is associated with changing to a lower rent. To test whether the influence of these geographical variables only related to *Section* 2, Model 3 of Table 6-3 was replicated setting each section in turn as the reference category (Table 8-15). The 'better' *sections, Section* 2 and 6, have a positive association with the change in rent, meaning that living in these *sections* is associated with seeing an increase in rent paid, as compared with the other *sections*. The 'less good' *sections, Sections* 5, 7 and 8, all have a negative association with the

change in rent. All models have a very low R^2 value, indicating that the variables available explain only a very small amount of the change in rent.

Table 8-15. Association of *sections* on the change in rent one year/move after bereavement, changing the reference section

	(1)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	-0.775	-0.135	-2.267***	-1.747***	-0.620*	-1.880***	-1.317**
	(0.625)	(0.421)	(0.657)	(0.496)	(0.305)	(0.466)	(0.411)
Persons per room	0.329	0.329	0.329	0.329	0.329	0.329	0.329
	(0.226)	(0.226)	(0.226)	(0.226)	(0.226)	(0.226)	(0.226)
Medium occupational status	0.819.	0.819.	0.819.	0.819.	0.819.	0.819.	0.819.
	(0.448)	(0.448)	(0.448)	(0.448)	(0.448)	(0.448)	(0.448)
Low occupational status	0.731	0.731	0.731	0.731	0.731	0.731	0.731
	(0.789)	(0.789)	(0.789)	(0.789)	(0.789)	(0.789)	(0.789)
Section 1		-0.640**	1.492***	0.972***	-0.156	1.105***	0.542*
		(0.228)	(0.150)	(0.181)	(0.456)	(0.218)	(0.241)
Section 2	1.221**	0.581**	2.713***	2.193***	1.066***	2.326***	1.763***
	(0.434)	(0.207)	(0.435)	(0.262)	(0.037)	(0.225)	(0.219)
Section 3	0.640**		2.132***	1.612***	0.485*	1.745***	1.182***
	(0.228)		(0.257)	(0.078)	(0.231)	(0.058)	(0.068)
Section 4	-1.492***	-2.132***		-0.520**	-1.648***	-0.387.	-0.951**
	(0.150)	(0.257)		(0.188)	(0.456)	(0.222)	(0.302)
Section 5	-0.972***	-1.612***	0.520**		-1.127***	0.133***	-0.430***
	(0.181)	(0.078)	(0.188)		(0.282)	(0.038)	(0.127)
Section 6	0.156	-0.485*	1.648***	1.127***		1.261***	0.697**
	(0.456)	(0.231)	(0.456)	(0.282)		(0.244)	(0.240)
Section 7	-1.105***	-1.745***	0.387.	-0.133***	-1.261***		-0.564***
	(0.218)	(0.058)	(0.222)	(0.038)	(0.244)		(0.111)
Section 8	-0.542*	-1.182***	0.951**	0.430***	-0.697**	0.564***	
	(0.241)	(0.068)	(0.302)	(0.127)	(0.240)	(0.111)	
R2	0.059	0.059	0.059	0.059	0.059	0.059	0.059
Number of observations	135	135	135	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. The reference category for section is Section 1 in (1), Section 3 in (3), etc. Least squares estimate, with robust standard errors clustered on section, shown in brackets. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The number of children living at home was also added to the models in Table 6-4 in the main text, to test if this impacted on the results. The addition of this variable made no significant contribution to the model (Table 8-16).

Table 8-16. Association of variables on the change in rent one move/year after bereavement, including number of children living in the household

	(1)	(2)	(3)	(4)	(5)	(6)
(Intercept)	-0.071	0.163	-0.221	0.558*	0.446	1.319.
	(0.429)	(0.355)	(0.249)	(0.238)	(0.291)	(0.795)
Persons per room	0.300	0.465	0.451	0.508	0.329	0.508
	(0.219)	(0.394)	(0.390)	(0.415)	(0.226)	(0.415)
Number of children		-0.306	-0.305	-0.325		-0.325
		(0.332)	(0.344)	(0.353)		(0.353)
High occupational status						-0.761
						(0.756)
Medium occupational status			0.461	0.775	0.819.	0.014
			(0.452)	(0.496)	(0.448)	(1.038)
Low occupational status			0.444	0.761	0.731	
			(0.613)	(0.756)	(0.789)	
Section 1				-1.025***	-1.221**	-1.025***
				(0.243)	(0.434)	(0.243)
Section 3				-0.431***	-0.581**	-0.431***
				(0.084)	(0.207)	(0.084)
Section 4				-2.724***	-2.713***	-2.724***
				(0.460)	(0.435)	(0.460)
Section 5				-2.040***	-2.193***	-2.040***
				(0.129)	(0.262)	(0.129)
Section 6				-0.815**	-1.066***	-0.815**
				(0.295)	(0.037)	(0.295)
Section 7				-2.206***	-2.326***	-2.206***
				(0.116)	(0.225)	(0.116)
Section 8				-1.601***	-1.763***	-1.601***
				(0.109)	(0.219)	(0.109)
R2	0.023	0.040	0.041	0.077	0.059	0.077
Number of observations	135	135	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. Least squares estimate with robust standard errors clustered on section shown in brackets. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

The analyses in Table 6-4 were also repeated using the *section* the family lives in after the first move/year rather than the one they originally lived in, and this output is shown in Table 8-17. The output remains similar except that living in *Section* 5 now has a positive impact on the level of rent compared with *Section* 2, with all other *sections* still having a negative impact.

Table 8-17. Socioeconomic and other conditions and the change in rent after one move/year, using *section* moved to.

	(1)	(2)	(3)	(4)
(Intercept)	-0.071	-0.478*	0.662+	1.456*
	(0.359)	(0.209)	(0.375)	(0.677)
Persons per room	0.300	0.287	0.343	0.343
	(0.211)	(0.199)	(0.208)	(0.208)
High occupational status				-0.795
				(0.762)
Medium occupational status		0.501	0.526.	-0.269
		(0.317)	(0.291)	(0.844)
Low occupational status		0.402	0.795	
		(0.724)	(0.762)	
Section 1			-2.326***	-2.326***
			(0.416)	(0.416)
Section 3			-0.715***	-0.715***
			(0.177)	(0.177)
Section 4			-2.659***	-2.659***
			(0.452)	(0.452)
Section 5			1.662***	1.662***
			(0.168)	(0.168)
Section 6			-0.880***	-0.880***
			(0.010)	(0.010)
Section 7			-2.189***	-2.189***
			(0.148)	(0.148)
Section 8			-1.888***	-1.888***
			(0.159)	(0.159)
R2	0.023	0.025	0.100	0.100
Number of observations	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. Least squares estimate with robust standard errors clustered on section shown in brackets. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

These regressions including ‘wife can continue business’ were also run excluding the number of children under 11. The coefficients remain negative, but ‘wife can continue business’ loses any statistical significance below the 10% level, except in Model 1. These results are shown in Table 8-18.

Table 8-18. Association of variables including wife can continue business with the change in rent one year/move after

	(1)	(2)	(3)	(4)
(Intercept)	0.150	-0.231	0.547	1.197.
	(0.522)	(0.291)	(0.353)	(0.697)
Persons per room	0.265	0.253	0.310	0.310
	(0.228)	(0.227)	(0.253)	(0.253)
Wife can continue business	-0.572.	-0.616	-0.294	-0.294
	(0.294)	(0.424)	(0.573)	(0.573)
High occupational status				-0.650
				(0.907)
Medium occupational status		0.507	0.802.	0.152
		(0.468)	(0.458)	(1.127)
Low occupational status		0.260	0.650	
		(0.710)	(0.907)	
Section 1			-1.174*	-1.174*
			(0.512)	(0.512)
Section 3			-0.578**	-0.578**
			(0.212)	(0.212)
Section 4			-2.631***	-2.631***
			(0.557)	(0.557)
Section 5			-2.046***	-2.046***
			(0.508)	(0.508)
Section 6			-1.002***	-1.002***
			(0.096)	(0.096)
Section 7			-2.277***	-2.277***
			(0.301)	(0.301)
Section 8			-1.738***	-1.738***
			(0.260)	(0.260)
R2	0.027	0.029	0.060	0.060
Number of observations	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. Includes wife can continue business but excludes number of children living in the household. Least squares estimate with robust standard errors clustered on section. Number of observations: 135 households; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

When the models looking at manual status (Table 6-5) were re-run including children living at home (Table 8-19) all statistical significance at the 10% or below disappeared.

Table 8-19. Socioeconomic and other conditions and the change in rent after one move/year, manual occupations.

	(1)	(2)	(3)	(4)	(5)
(Intercept)	-0.071	0.163	-0.119	1.047*	0.974*
	(0.429)	(0.355)	(0.242)	(0.439)	(0.481)
Persons per room	0.300	0.465	0.388	0.450	0.269
	(0.219)	(0.394)	(0.397)	(0.434)	(0.254)
Number of children		-0.306	-0.310	-0.331	
		(0.332)	(0.328)	(0.339)	
Manual occupation			0.813*	0.841*	0.824.
			(0.403)	(0.415)	(0.452)
Section 1				-1.175***	-1.389***
				(0.150)	(0.222)
Section 3				-0.680***	-0.838***
				(0.168)	(0.146)
Section 4				-2.794***	-2.779***
				(0.461)	(0.437)
Section 5				-1.938***	-2.096***
				(0.126)	(0.208)
Section 6				-0.761**	-1.011***
				(0.247)	(0.020)
Section 7				-2.276***	-2.396***
				(0.124)	(0.195)
Section 8				-1.794***	-1.970***
				(0.244)	(0.127)
R2	0.023	0.040	0.050	0.084	0.065
Number of observations	135	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. Least squares estimate with robust standard errors clustered on section. Number of observations: 135 households; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Table 6-3, considering low, medium and high status occupations, was also repeated without clustered standard errors (see Table 8-20) and once again all statistical significance disappears.

Table 8-20. Association of variables with the percentage change in rent one move/year after bereavement, no clustering

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-0.071	-0.478.	0.446	1.177
	(0.376)	(0.255)	(1.639)	(2.098)
Persons per room	0.300	0.287	0.329	0.329
	(0.194)	(0.202)	(0.224)	(0.224)
High occupational status				-0.731
				(1.167)
Medium occupational status		0.501.	0.819.	0.088
		(0.300)	(0.425)	(1.168)
Low occupational status		0.402	0.731	
		(1.006)	(1.167)	
Section 1			-1.221	-1.221
			(2.004)	(2.004)
Section 3			-0.581	-0.581
			(1.861)	(1.861)
Section 4			-2.713	-2.713
			(1.792)	(1.792)
Section 5			-2.193	-2.193
			(1.758)	(1.758)
Section 6			-1.066	-1.066
			(1.889)	(1.889)
Section 7			-2.326	-2.326
			(1.733)	(1.733)
Section 8			-1.763	-1.763
			(1.703)	(1.703)
R^2	0.023	0.025	0.059	0.059
Number of observations	135	135	135	135

Notes: Estimates shown for the specification in equation [7]. Least squares estimate with robust standard errors not clustered. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

In the main text, if the occupational status of the deceased head of household was divided into a binary option of manual or non-manual worker, having been a manual worker is associated with paying a higher rent following the first year/move, although the association is not highly statistically significant (Table 6-5). This regression was re-run without clustering at the *section* level, and all statistical significance disappears (Table 8-21).

Table 8-21. Association of variables with change in rent one move/year after bereavement, manual occupational status, no clustering

	Model 1	Model 2	Model 3
(Intercept)	-0.071	-0.349	0.974
	(0.376)	(0.312)	(1.604)
Persons per room	0.300	0.223	0.269
	(0.194)	(0.191)	(0.222)
Manual occupational status		0.794	0.824
		(0.501)	(0.519)
Section 1			-1.389
			(1.859)
Section 3			-0.838
			(1.853)
Section 4			-2.779
			(1.743)
Section 5			-2.096
			(1.683)
Section 6			-1.011
			(1.805)
Section 7			-2.396
			(1.692)
Section 8			-1.970
			(1.662)
R^2	0.023	0.033	0.065
Number of observations	135	135	135

Notes: Estimates shown for the specification in equation [7]. Least squares estimate with robust standard errors, not clustered. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Variance inflation factors were calculated for independent variables including 'wife can continue business' and 'number of children', to test for collinearity. The results are shown in Figure 8-11 and indicate that there are no issues with multicollinearity, with all values being less than 2.

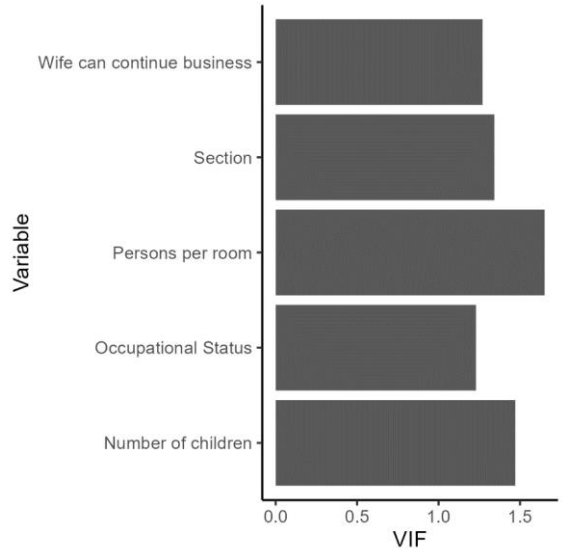


Figure 8-12. Variance inflation factor (VIF) for variables included in above tables

Table 8-22 and Table 8-23 show output including number of children living at home, but for the second move or year after the death of the breadwinner. This additional variable has no statistical significance.

Table 8-22. Socioeconomic variables and change in rent two moves or two years after the death of the head of household, including number of children

	(1)	(2)	(3)	(4)	(5)
(Intercept)	-0.074	0.318	0.025	0.616	1.404*
	(0.304)	(0.418)	(0.313)	(0.553)	(0.591)
Persons per room	0.295	0.549	0.540	0.645	0.645
	(0.239)	(0.447)	(0.442)	(0.488)	(0.488)
Number of children		-0.471	-0.466	-0.491	-0.491
		(0.381)	(0.390)	(0.415)	(0.415)
High occupational status					-0.788
					(0.793)
Medium occupational status			0.358.	0.857*	0.068
			(0.201)	(0.375)	(0.518)
Low occupational status			0.220	0.788	
			(0.623)	(0.793)	
Section 1				-2.071***	-2.071***
				(0.157)	(0.157)
Section 3				0.318+	0.318+
				(0.189)	(0.189)
Section 4				-3.130***	-3.130***
				(0.634)	(0.634)
Section 5				-2.028***	-2.028***
				(0.219)	(0.219)
Section 6				-0.875***	-0.875***
				(0.231)	(0.231)
Section 7				-2.338***	-2.338***
				(0.108)	(0.108)
Section 8				-1.661***	-1.661***
				(0.246)	(0.246)
R2	0.027	0.072	0.073	0.166	0.166
Number of observations	120	120	120	120	120

Notes: Estimates shown for the specification in equation [7]. Compares low and medium occupational status against high status, including number of children. Least squares estimate with robust standard errors clustered on section. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Table 8-23. Socioeconomic variables and the change in rent two moves/years after the death of the head of household, manual workers, including number of children

	(1)	(2)	(3)
(Intercept)	0.318	0.063	1.311*
	(0.418)	(0.274)	(0.615)
Persons per room	0.549	0.481	0.604
	(0.447)	(0.405)	(0.467)
Number of children	-0.471	-0.471	-0.497
	(0.381)	(0.377)	(0.407)
Manual occupation		0.698	0.662
		(0.619)	(0.537)
Section 1			-2.276***
			(0.131)
Section 3			-0.010
			(0.131)
Section 4			-3.308***
			(0.708)
Section 5			-2.083***
			(0.223)
Section 6			-0.954***
			(0.205)
Section 7			-2.471***
			(0.140)
Section 8			-1.934***
			(0.207)
R2	0.072	0.079	0.168
Number of observations	120	120	120

Notes: Estimates shown for the specification in equation [7]. Least squares estimate with robust standard errors clustered on section. Number of observations: 120 households; *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Table 8-24 and Table 8-25 show output for the second move or year after the death of the breadwinner, with no clustering. The statistical significance of the *sections* disappears.

Table 8-24. Association of other variables with the percentage change in rent two moves/years after the death of the head of household, no clustering

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-0.074	-0.468.	0.336	1.148
	(0.382)	(0.270)	(2.178)	(2.466)
Persons per room	0.295	0.289	0.369	0.369
	(0.202)	(0.215)	(0.242)	(0.242)
High occupational status				-0.811
				(1.356)
Medium occupational status		0.495.	0.972.	0.161
		(0.258)	(0.573)	(1.210)
Low occupational status		0.232	0.811	
		(1.204)	(1.356)	
Section 1			-2.288	-2.288
			(2.054)	(2.054)
Section 3			0.107	0.107
			(2.326)	(2.326)
Section 4			-2.981	-2.981
			(2.110)	(2.110)
Section 5			-2.422	-2.422
			(2.076)	(2.076)
Section 6			-1.113	-1.113
			(2.240)	(2.240)
Section 7			-2.444	-2.444
			(2.046)	(2.046)
Section 8			-1.923	-1.923
			(2.048)	(2.048)
R^2	0.027	0.029	0.118	0.118
Number of observations	120	120	120	120

Notes: Estimates shown for the specification in equation [7]. Includes occupational status. Least squares estimate with robust standard errors, not clustered. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Table 8-25. Socioeconomic variables and the change in rent two moves/years after the death of the head of household, manual workers, no clustering

	Model 1	Model 2	Model 3
(Intercept)	-0.074	-0.328	1.144
	(0.382)	(0.324)	(1.940)
Persons per room	0.295	0.228	0.324
	(0.202)	(0.201)	(0.233)
Manual occupational status		0.692	0.662
		(0.463)	(0.487)
Section 1			-2.527
			(1.984)
Section 3			-0.259
			(2.239)
Section 4			-3.168
			(2.064)
Section 5			-2.496
			(2.016)
Section 6			-1.204
			(2.153)
Section 7			-2.591
			(1.994)
Section 8			-2.235
			(1.986)
R^2	0.027	0.034	0.119
Number of observations	120	120	120

Notes: Estimates shown for the specification in equation [7].: Least squares estimate with robust standard errors, not clustered. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

An interaction term was added to the regressions, based on Models 3 and 4 in Table 6-3 and this output is shown in Table 8-26. As using each *section* would create a large number of interaction terms, the *sections* are divided into two groups, with *Section* 2 or 6 representing the better off *sections*.

Table 8-26. Output including interaction term for section groups

	Model 3	Model 4
(Intercept)	-0.496*	-0.112
	(0.208)	(0.648)
Persons per room	0.299	0.299
	(0.216)	(0.216)
High occupational status		-0.384
		(0.626)
Medium occupational status	0.340	-0.044
	(0.501)	(0.914)
Low occupational status	0.384	
	(0.626)	
Section 2 or 6	0.021	0.021
	(0.105)	(0.105)
Medium occupational status × Section 2 or 6	0.706	0.706
	(0.557)	(0.557)
Number of observations	135	135
R2	0.029	0.029

Notes: Estimates shown for the specification in equation [7]. The 8 sections are grouped into two, with sections 2 and 6 being the better off sections and all other sections being in the alternative group. The dependent variable is the percentage change in rent between the base year and the first year/move.Least squares estimate with robust standard errors, not clustered. *** p < 0.001; ** p < 0.01; * p < 0.05; . p < 0.10; p-values are based on two-sided t-tests of statistical significance of the coefficient.

Glossary

TERM USED	EXPLANATION
Breadwinner	Male head of household who contributes the majority of the income.
Cadastre	Annual lists of properties retained by French municipalities, which included names of owners.
Consumption smoothing	Borrowing or saving at various periods of life in order to permit relatively equal consumption (expenditure) over a lifetime, even though income may vary.
GeoTIFF	A digital file that embeds geo-spatial metadata from, e.g., digitised maps, so that the georeferencing information is available for use by other applications.
Midden	A rubbish heap which in the nineteenth century would include both food waste and human excrement.
Mortality transition	A sustained decline in mortality rates from high to low levels. In western Europe, this was seen from around 1870 to 1950.
Outdoor relief	Financial or non-monetary support given to people living in the community, as opposed to housing these people in institutions such as a workhouse.
Sigmoid	S-shaped or reverse S-shaped
Socioeconomic conditions	Variables which may indicate the socioeconomic status of an individual or household, such as occupation, rent paid, size of house, etc.
Wet nursing	The practice of babies and infants being breast-fed by someone other than the mother.

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