Infant Mortality Decline in Rural and Urban Bavaria: Sanitary Improvement and Inequality in Bavaria and Munich, 1825-1910[1]

Abstract

A high infant mortality regime characterized much of the German Kingdom of Bavaria during the long nineteenth century. Conditions in Munich were reflective of this regime, with 40 deaths per 100 births not uncommon during the early 1860s. Infant mortality in all of Bavaria declined slowly in rural areas until World War I. In urban areas, the decline was much more impressive with the median falling by one-half up to 1913. The decline in Munich was even more dramatic. This paper examines the causes of infant mortality in both Bavaria as a whole and in Munich. The analysis of Bavaria examines district-level data for the period 1880 through 1910. The examination of Munich is for the period 1825-1910, which is a period of substantial economic and social change as well as sanitary reform. Patterns of land distribution, fertility and sanitary provision all play a role in accounting for the decline in infant mortality. The study uncovered growing discrepancies across social groups as decline set in Munich.

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Introduction

An important achievement of pre-1914 western societies was an impressive reduction in infant mortality. Vallin (1991, Fig. 3.4) illustrates the pattern for most of Europe. With the exception of Russia, infant mortality rates began a steep decline starting some time during the 1890s that continued until World War. In Germany, for example, infant mortality fell by 34 percent from the early 1870s to 1915(see Knodel (1974, Table 4.1)). The decline in urban areas was even more dramatic. In Bavarian cities overall, the decline was about 50 percent from the early 1860s to 1912. In Munich, it was from about 450 deaths per 1,000 births in the early 1860s down to about 140 by 1912. The decline plays an important role in the history of the demographic transition, since high infant mortality contributed disproportionately to overll mortality rates (see Mayr (1870), for example).

The nature of the mortality regime that prevailed prior to the secular decline is a subject of debate. As Schofield, Reher et al. (1991) note, parish reconstitution studies have concluded that mortality stabilized in England and France during the 18th century with the decline of epidemic diseases such as smallpox and the end of subsistence crises. Estimates of national mortality rates and the expectation of life at birth available for England show stagnation during the first half of the nineteenth century and improvement only at the end of the century. Imhof's estimates for Germany show a secular decrease in mortality until about 1820 and then an increase in mortality up to the 1870s. The onset of rapid decline in the 1880s marks a permanent departure from the preceding pattern of mortality. Although the facts are reasonably well-established at the level of national populations, much less is known about mortality change in urban versus rural populations and how those changes may have interacted with different income groups.

This study examines patterns of infant mortality (both a rise and a decline) within the context of the Kingdom of Bavaria and its capital, Munich. In the 1820s, Bavaria was a primarily agricultural kingdom with a population found mostly in small villages and medium-sized towns. In the mid-1820s, the only city with a population in excess of 50,000 was Munich; the next two largest cities—Nuremberg and Augsburg—were about 30,000 each. From the 1820s to World War I, the kingdom's population grew by over 60 percent. By 1910, Bavaria had developed several modern industrial centers (including the largest cities of Augsburg, Nuremberg and Munich). Nuremberg had grown by ten times, and Munich's population had expanded by eight times. Munich in 1910 was the third largest city in Germany and the center of significant food processing and machine-making industries. This paper examines the impact of changes in several aspects of the economic, fertility and sanitary circumstances that may have influenced infant mortality in Bavaria until World War I. The analysis of district-level data identifies roles for patterns of farm size and religious affiliation in influencing the modest decline that took place in rural areas. In urban areas, the results suggest that changes in fertility behavior were important for understanding the decline. Data available for 1,000 Munich families on the circumstances of the individual birth and early life, the family and the surrounding urban environment allow for a closer look at the role sanitation, fertility outcomes and family economic circumstances on infant mortality. The results point to a significant and growing role for differentiation of outcomes according to the social and economic circumstances of families. At the same time, the provision of centrally piped water contributed to diminished rates of infant mortality.

Infant mortality: Debating patterns of change and causality

Spree (1995, Figure 1) summarizes published infant mortality rates for the southern German states of Bavaria and Württemberg for 1833 to the early 1870s and for Prussia from

1816 onwards. All three states show a secular rise in infant mortality that peaks ca. 1871 in Bavaria and as late as the 1880s in Württemberg. Less aggregated data are sparse. Szreter and Mooney (1998) argue based upon a range of sources that mortality actually rose in urban England up through the 1850s. (See also the discussion in Floud, Fogel et al. (2011, pp. 172-173)). van de Walle and Preston (1974) and Preston and van de Walle (1978) present evidence from Paris and several urbanizing French *départements* that infant and child mortality rose modestly from the end of the Napoleonic era until at least the 1880s or 1890s, only to then fall precipitously. Knodel (1988, p. 42) finds that for the 14 German villages in his study of *Ortssippenbücher*, average rural infant mortality rose from about 220 per 1,000 at the beginning of the 19th century to about 280 per 1,000 in 1850-1874; it then began a modest decline to the end of the century.

One reason for comparatively little evidence on infant or child mortality that spans periods of rapid urbanization was the difficulty of accurately measuring it. Mayr (1870) reviews the measurement issues that statisticians debated up through the early 1860s. To match the numerator (infants deaths) with the denominator (infants at risk), those in charge of maintaining records of vital events needed to record deaths by year of birth *and* age at death, not just by the age at death, which was the traditional practice for parish registers. In- and out-migration could confound rates calculated for smaller geographic areas. The presence of a lying-in hospital in a town that served the needs of indigent (often single) mothers from outlying rural districts could bias infant mortality rates upwards. If lower-income urban mothers placed their newborns with wet nurses located in rural areas, as was often the case in Bavaria, infant mortality rates might be biased downwards.[2]

Most of the focus of research has been on the causes of the decline in infant mortality. Consistent with long-standing debates about the causes of overall reductions in mortality, the literature focuses on three potential reasons for the decline: improved sanitation, improved infant care and higher standards of living, which led to improved maternal well-being. Most of the contemporary and modern literature agrees that a fall in deaths from gastro-intestinal disease accounted for the decline in infant mortality in North America and northern and western Europe. In urban Germany, for example, about 50-70 percent of infant mortality ca. 1870 could be attributed to diarrheal diseases; as late as the decade before World War I, the correlation between infant mortality and diarrheal disease was 0.75 for German cities with a population of 50,000 or more.[3] The incidence of the other major cause of infant death at the time, respiratory disease, does not seem have changed much. Neonatal mortality also did not show much of a decline during the decades up to the World War I. The sanitation view notes that rapid declines occurred within a few decades of the introduction of centrally provided piped water into the cities and water-born removal of human waste out of them with modern sanitary sewer systems. The infant care view argues that fundamental changes in (maternal) behavior, including the adoption of extended breastfeeding, protected infants from pathogens in the environment. The third standard

[2] van de Walle and Preston (1974, p. 90) describe the French version of this practice as the “industrie des nourrices,” Perhaps one-quarter of infants born in Paris were placed with wet nurses living outside of the city. Infants placed with a wet nurse in Germany were known as *Haltekinder* or *Kostkinder*. The practice was most common among single mothers.

[3] See Prausnitz (1901) and Vögele (1994) for Germany and Lee (2007) and Condran and Lentzner (2004) for the United States. Lee draws upon the detailed studies of the Children’s Bureau conducted during the second decade of the twentieth century.

of living perspective links the decline in infant mortality to the gradual amelioration of the sources of physical stress that placed a heavy burden on mothers with young infants.

The first two approaches to explaining infant mortality decline—sanitation and infant care—focus on the reduction in the incidence of gastro-intestinal. Curtis, Cairncross et al. (2000) offer a useful organizing framework for thinking about the individual and familial risks that changes in sanitation practices and enhanced infant care may have addressed. Figure 1 is also known as a 4F diagram, since it represents the four pathways of fecal-oral transmission by which infected fecal matter from an infant suffering gastro-intestinal disease can be ingested by another host.[4] Both perspectives take note of the fact that gastro-intestinal diseases overwhelmingly affected infants who were receiving some form of artificial feeding.

The sanitation view argues that infant mortality declined because of sanitary reform enacted in most cities of northern and western Europe and North America during the last third of the nineteenth century and into the first decades of the twentieth. Sanitary reform included simply providing piped water, then ensuring that water supplies were of high quality (through filtration or treatment with chlorine) and finally installing sanitary sewer systems that allowed the introduction of flush toilets.[5] Woods, Watterson et al. (1988) downplay the importance of sanitary reform for the decline in infant mortality in Britain, since the major efforts at reform predated the decline by several decades. Szreter, 1988 #421} also acknowledges that reducing the incidence of food-borne diseases was primarily responsible for the decline in infant gastro-

[4]See Curtis, Cairncross et al. (2000).

[5] It appears that the sewer outflow, and the consequences for it, differed substantially across countries. Cities relying upon groundwater wells or impoundments for their water supplies would see less of a benefit from filtration than would cities that relied primarily upon surface water. If local regulations prohibited disposal of sanitary sewer effluent in waterways, as they did in some German states, spillovers into water supplies would be much less of a problem than was the case in the United States, where apparently the dumping if raw sewage into rivers was widespread.

enteritis. Condran and Lentzner (2004) provides a detailed study of the timing of various sanitary interventions in Pittsburgh, New Orleans and New York also expresses skepticism that improved sanitation could be responsible for a decline in infant deaths in their case studies of U.S. cities. Condran and Lentzner (2004, pp. 349-352) argue that much of the observed decline in the summer peak in infant mortality, which stands in as a marker for mortality from gastro-enteritis, took place in their study cities prior to the major sanitary interventions and improvements in milk supplies. Even the periods of intervention do not necessarily coincide with steep declines in infant mortality.[6] Cutler and Miller (2005) find results that are at variance with the earlier literature. They argue that cleaner piped water supplies—particularly filtering the surface water used in a large number of U.S. American cities— accounted for a three-quarters reduction in infant mortality in 12 cities over the period 1900 through 1936.[7]

Gastro-enteritis can be transmitted through polluted water supply, but the primary means of transmission appears to be through the fecal-oral route. Interventions made possible by the standard program of sanitary reform could sever some of the other paths for re-infection suggested by Figure 1. They include the availability of flush toilets (intervention ①) and abundant water supplies available from a tap in the (intervention ②).[8] The installation of flush toilets, by no means a given in nineteenth cities, allowed for the immediate removal of feces from the home and would constitute a primary method of defense. Clean—and plentiful—water allowed for washing food or feeding bottles that could come in direct contact with infants and for

[6] The literature that assesses the relative effectiveness of public health interventions in contemporary developing countries offers some guidance, but considerable uncertainty remains. Fewtrell, Kaufmann et al. (2005, Table 3) cites a study that concluded that a water supply intervention in Zambia lowered the risk of typhoid morbidity of to 15% of pre-intervention rates, while the reduction of morbidity from diarrheal disease was substantially less: to about 60% of pre-intervention rates. It should be noted that the study quality was viewed as poor by the author.
[7] The reduction in infant mortality was from 18.9 to 11.9 per 100 between 1900 and 1920.
[8] Or in terms of the terminology used by the World Health Organization, infant diarrhea could be viewed as a “water washed” disease rather than just a “water-borne” disease.

cleaning surfaces in the household that had come into contact with fecal matter. Plentiful water also meant that caregivers or others who came into contact with an infected infant could wash their hands after contact and reduce the risk of further infection.

Kintner (1988) focuses on changes in the infant care practices of women. Newsholme (1910) summarizes the perspective of many of his contemporaries that “Ignorance and Fecklessness of Mothers” was at the root of high rates of infant mortality. Newsholme and others focused their attention primarily upon feeding practices. Breastfeeding mothers often would give their children tastes of food that the mothers had handled or had already chewed. Mothers who had weaned their infants or were in the process of weaning gave their infants foods that were inappropriate and often prepared under unsanitary conditions. Newsholme and many others associated these practices primarily with working class women.Rochester, Hunter et al. (1923) found evidence that confirmed this view. Lower-income mothers in Baltimore were more likely to work outside of the home and also less likely to breastfeed. The evidence from Germany is less clear-cut. Baum (1912, p. 208) found only about six percent of married woman chose to end breast feeding because of work outside of the home in the textile town of Grevenbroich.[9] Lübbering (1912. Table X) found an inverted U-shaped relationship between the propensity to breastfeed and income in the steel center of Essen. Wives of the lowest-income workers and the highest-income residents were least likely to breastfeed. Lower- and lower-middle income wives were the most likely to breastfeed. Jordan (1912, p, 82) found a similar pattern in his study of residents of the Hannover industrial suburb of Linden. Bremme (1913, p. 398) concluded from his analysis of mothers in Dresden that women married to wage workers (*Arbeiter*) were

[9] Among single mothers, the share was about 50 percent (see Bremme (1913)).

somewhat less likely to use “natural” feeding than those with higher incomes, but the difference was only one of degree.

Kinter argues that the burgeoning infant welfare movement of the early 20th century played an important role in bringing about improvements in infant care practices in more general terms. An arm of the “new public health” movement, which focused on changing unhealthy behaviors, the infant welfare movement provided information about effective infant care practices to working class mothers (particularly breastfeeding), offered incentives for mothers to breastfeed and worked to secure greater access to clean milk supplies. Ewbank and Preston (1990) argue in a similar vein that improvements in infant care account for the decline in infant mortality in the United States. Brown (2000) finds some empirical support for this view in his study of the spread of infant health centers and other initiatives in mid- and large-sized German cities during the decade or so before the war. The modern literature on developing countries provides some support for this view. Simply providing clean water is not the same thing as introducing hygienic practices into the household. Curtis and Cairncross (2003) have found that regular washing of hands with soap is three times as effective in reducing diarrheal disease as the introduction of clean water.

The inequality view focuses on the causal relationship between low income and infant mortality prior to the establishment of the social services and income supports provided by functioning welfare states. Millward and Bell (2001) highlight the economic and physical stress that accompanied working class life during the nineteenth century. These conditions influenced the health of the mother and her physical ability to take care of an infant (including being physically able to breastfeed). Her prior fertility history, a high risk of contracting tuberculosis and the demands of work outside of the home would have the strongest impact on working class women.

A high fertility regime with closely-spaced births would have exacerbated these sources of stress. Pebley, Hermalin et al. (1991) provide a helpful taxonomy for how shortened inter birth intervals that often accompany high fertility may have mattered. A short inter birth interval may lead to maternal depletion. Closely-spaced infants could also compete for resources and the attention of the mother. Short inter birth intervals may also stand in for conditions more likely to lead to exposure to diarrheal disease. A short birth interval combined with the survival of the prior birth would increase the likelihood of introducing feces from older siblings into the environment and increase the likelihood of spreading infection (particularly in the absence of breastfeeding) via the fecal-oral route (see Figure 1).[10] In addition, a short inter birth interval may also indicate that the mother weans her infant shortly after birth, which would heighten the risk of an infant death by increasing exposure to potential pathogens in the environment and in ingested food via the pathways outlined in Figure 1.[11] Some studies have identified birth order (or age of the mother) as a potential risk factor, both because of the potential for increased maternal depletion with higher-order children and the increase in the likelihood that the infant would never be breast-fed or breast-fed for only a shortened period.[12]

An implication of the inequality perspective is that infant mortality varied substantially across social and economic classes. The literature disagrees over whether such disparities existed. Spree (1995) argues on the basis of occupational classifications and aggregated district-

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[10] See also Rutstein (2005) for a comprehensive analysis of Demographic and Health Surveys from 17 developing countries, which reaches similar conclusions about the risk a short inter birth interval poses to the index child.
[11] See Prausnitz (1901) and Rietschel (1911) with the accompanying discussion about the importance of pathogens in milk compared with other causes for high infant mortality.
[12] Bremme (1913) provides evidence from his study of Dresden women.

level data from Prussia for 1877 to 1901 that growing social-economic differences were an important feature of infant mortality decline over the period. Infant mortality declined among families headed up by the self-employed, civil servants and clerks in urban areas. Other groups (skilled and unskilled workers and farm laborers) saw little or no improvement. Other studies of the period of the decline show only a modest contribution of differentials in income at best. Haines (1995) uses aggregated data from the British 1911 Census to test the results of Watterson (1986), which found little role for income or extreme poverty in explaining patterns of the estimated decline in infant mortality in Britain over the period 1895 to 1911. Haines' results were mixed, but offered some support for a role for differentials in class, but not for income. The British data from prior to World War I also suggest that living in a rural setting could more than offset all of the advantages of wealth for urban dwellers.

Studies using micro data on individual births or families have generally had limited success at identifying a steep income gradient. Knodel (1988, p. 74) finds that measures of socio-economic differentiation available in the *Ortssippenbücher*, or German village genealogies, had little explanatory power in accounting for infant survival. Lynch and Greenhouse (1994) use a sample of microdata from both urban and rural Sweden during a period that bracketed the onset of infant mortality decline. Their results also suggest that differentials in infant mortality were unresponsive to admittedly crude measures of socio-economic standing. Edvinsson, Brandstrom et al. (2005) expand the analysis of Swedish data for the period 1803 to 1900 to two regions, both of which experienced substantial declines in infant mortality. They find that a disproportionately small share of women accounted for well over one-half of infant deaths. Their analysis of the determinants of clustering in infant mortality by families concludes that social-economic circumstances played virtually no role in the mostly rural Skellefteå region. In the

Sundsvall region, an area with limited breast feeding that experienced a boom in the sawmill industry, peasant families were at the highest risk of experiencing infant mortality and other groups (particularly 200 families belonging to the highest social class) were at a lower risk. Finally, Poppel, Jonker et al. (2005) study infant and early childhood mortality in three Dutch provinces over the period 1812 to 1909. As with Edvinsson, Brandstrom et al. (2005), the Dutch study covers almost a century of mortality experience. The Dutch provinces they examine all experienced increases in infant mortality until a peak in the 1850s (Zealand) or the 1870s (Friesland and Utrecht), when rapid decline set in. The sample is a matched sample of infant births with population registry data. The drawback is that for 13 to 20 percent of the births, whether or not the infant survived could not be determined. Their analysis includes several variables classifying socio-economic status as well as some other indicators of the location of the birth. Indicators also include the age of the father and the marital status of the mother (unmarried versus married). The results of likelihood ratio tests confirm the importance of the social class variables, but the pattern over time is not consistent. Nor is it consistent across provinces. Two studies using data from the U.S. population censuses, Preston and Haines (1991, pp. 154-156) and Ferrie (2003), failed to uncover significant social-economic differentials.

Engerman and Kunitz (1992) provide an overview of the several types of hetereogeneity among families that could overwhelm the direct impact of income or social class on mortality. For infants, birth spacing and feeding practices that may be presumed to be independent of income could have a profound influence on the probability of survival. With the exception of Knodel (1988, pp. 88=89), an important deficiency of the micro-based studies is that they generally do not include information on the prior birth interval. As noted above, short inter birth intervals may have adversely affected infant survival. In addition, they do not address the issue of unmeasured hetereogeneity among families. Lynch and Greenhouse (1994) first recognized the importance of family-specific influences on infant mortality, which Edvinsson, Brandstrom et al. (2005) attempt to analyze.[13] Lynch's approach, which controls for the mortality outcomes of prior births, leaves unanswered the source of high infant mortality among particular families.

Infant Mortality Decline: The Case of Bavaria before the First World War

This study takes a two stage approach to understanding influences on the decline in infant mortality with a focus on conditions in the German Kingdom of Bavaria prior to World War I. Analysis of aggregate data for rural and urban districts from 1880 onwards helps to identify features of local economies or populations that may matter. An unusual data set from Bavaria's capital city, Munich, during the period 1825 through 1910 allows a more in-depth look at micro-level determinants. Figure 2 shows the box and whisker plots of the distribution of infant mortality across Bavaria from the 1830s through 1910.[14] The graph also includes the overall infant mortality rate for the same periods for the city of Munich, Bavaria's capital and largest city. Infant mortality rates showed a tendency to rise through the mid- to late-1860s. By the time data that distinguish between urban and rural districts are available, it is clear that some districts exhibited almost unimaginable infant mortality. Rates in several urban *and* rural districts exceeded 50 percent. Unlike the well-known English pattern, city-countryside differentials are not as substantial as the gap between Manchester or Oldham and rural registration districts.

[13] Perhaps because of limitations in the source material, the recent micro-analysis of van Poppel, Jennissen et al. (2008) fails to account for family-specific influences.

[14] The modern administrative organization of Bavaria dates from the early 1860s, when the administrative districts known as *Bezirksämter* (BAs) were set up for rural and urban areas. Although the urban districts were known as *Unabhängige Städte* (independent cities), we describe them as urban BAs to simplify the discussion. Data reported for the rural BAs exclude the data for any urban BAs that may lie within their boundaries or are adjacent. Data prior to the 1860s are only available at the level of one of Bavaria's nine provinces. Because the Bavarian administrative districts west of the Rhine in the Rhenish Palatinate had a different administrative structure, data are not available that distinguish between infant mortality in urban versus rural districts. For that reason, this region is excluded from the subsequent discussion and analysis.

Cities were lethal, but so were many rural areas. The overall distributions at the beginning of the period reveal a spread that would span the national averages for most of north and west Europe. The median remained stubbornly high in urban and rural areas through the 1880s only to start a steady decline from the late 1880s through the years just prior to World War I. Consistent with the experience of other European countries, the improvement in urban areas generally outpaced the decline in rural areas and accelerated after 1900. Munich's experience is an amplified version of this pattern. Peaking at almost 50 per 100 in the early 1860s, the rate declines rapidly so that by 1910, it is one-third of the peak. The decline moved Munich from the top of the third quartile of Bavarian towns in the 1860s to the middle of the second quartile by 1910.

Mayr (1870)'s comprehensive account of Bavarian infant mortality based upon data from the 1860s acknowledges the widespread opinion that infancy was exceptionally lethal for Bavarian newborns. Along with Württemberg, the other large south German state, Bavaria's chronically high average rate of infant mortality rate of 30 per 100 live births stood out among the German states and the rest of Europe. Mayr's analysis points out that the wide spread among districts evident in Figure 2 reflects substantial geographical disparities. Rates ranged from 20 per 100 in the northeastern Bavarian province of Upper Franconia up to 40 per 100 in Swabia and Upper Bavaria in southern Bavaria. Typical for infant mortality in much of north and west Europe and North America, the leading cause of infant death was high rates of mortality from gastro-intestinal disease. In the case of Bavaria, Mayr concludes that overall 60 percent of infant deaths could be attributed to gastro-intestinal disease.[15] Mayr (1870, p. 218) concludes that "inadequate nutrition and care of infants"—primarily the lack of breastfeeding—explains this

[15] The nosology in use at the time focused primarily on symptoms rather than the organs affected. The three diseases in question are *Durchfall* (diarrhea), *Fraisen* (Spasms) and *Atrophie im ersten Lebensjahre* (atrophy in the first year of life).

pattern of infant deaths. He attributes this deficiency to the dominance in the schooling system of celibate Catholic nuns and priests, who would have no knowledge of how best to care for infants.

Accounting for Infant Mortality in Bavaria

By the time of his comprehensive survey, Roetzer (1913) could offer a number of explanations for why infant mortality in the core region of "Old Bavaria" remained high when compared with the rest of western and northern Europe.[16] Roetzer concurs with Mayr's assessment that inadequate infant feeding and care (limited breastfeeding and of short duration) constituted the primary proximate cause, but he directs his attention to social and economic conditions that may have led to these practices. Filthy conditions prevailing in farm homes and barnyards meant it was very difficult to keep other forms of food that were fed to infants, such as rice water, acorn coffee or flour porridge, clean and thus prevent infection via the food and fingers pathways. Poor housing conditions in some urban areas could have a similar impact. A key barrier to domestic hygiene was the absence of readily available clean water, either because existing wells were polluted or simply because of water scarcity. Roetzer draws on a number of studies of rural conditions to argue that the main reason for the limited amount of breastfeeding was that farming practices demanded that mothers spend considerable time working in the fields. The demands were most acute in lowland areas where farms specialized in cultivation of the arable in upland and mountain regions, where dairying and other forms of animal husbandry were important. Most family farms of less than 20 hectares could not afford to hire outside "servants," which meant that field work would place heavy demands on the time and energy of mothers. Employment of married women in industry would be expected to have an impact as

[16] Old Bavaria (*Altbayern*) included the provinces of Upper Bavaria, Lower Bavaria and the Upper Palatinate. Much of what Roetzer wrote about Altbayern could be applied to the other southern Bavaria province centered on Augsburg, Swabia.

well, although this was most likely the case in the textile towns of Swabia or Upper Franconia. Finally, several observers saw a close link between limited breastfeeding, shortened birth intervals, high fertility rates and high infant mortality rates. Roetzer acknowledges that many traditional feeding practices, when coupled with minimal breastfeeding, could lead to elevated infant mortality.[17]

Accounting for Infant Mortality in Bavarian Districts

Data available at the level of rural and urban *Bezirksämter* (BA) for the period 1880-1910 allow us to examine several of the explanations for patterns of infant mortality found in the literature during most of the period of the decline in infant mortality.[18] Rural BAs had relatively small populations during the period of analysis of only about 28 thousand. Most urban districts were also of a modest size with an average of only 33 thousand people. Our panel has cross-sections on all of the relevant variables for the years 1880, 1895 and 1910. The rural districts can include some sizeable urban communes (*Gemeinden*). On average, 12 percent of residents in a "rural" BA lived in a place of 2000 or more person. The urban districts reflect a legal definition of a town as an administrative center. For weighting regressions we use the average number of births in a BA over the three cross-sections.[19] The panels are slightly unbalanced, with 411 observations in 138 rural Bas, and 113 observations on 38 urban BAs.[20] In all specifications, the

[17] It was apparently not uncommon for mothers to pre-chew solid food intended for their infants. Pacifiers made of rags dabbed in sugar water would offer multiple opportunities for contamination.
[18] Brown and Guinnane (2007) provide a detailed description of the sources used to construct the dataset used in this analysis.
[19] We estimated the IV models using stata's xtivreg2. The weights are what Stata calls "analytic" weights that are inversely proportional to an observation's variance.
[20] Administrative boundary changes during the late 1870s and early 1880s limit the ability to include a full panel for several districts in the Upper Palatinate.

dependent variable is the average infant mortality rate for the five-year period centered on the year of the cross-sectional information.

To the greatest extent possible, the analysis of influences on infant mortality draws on the three main themes of the historical literature on infant mortality noted above: the role of domestic and local sanitary conditions, the role of infant care practices (particularly breastfeeding) and the impact of the fertility regime and health of the mother.[21] The most important demographic control is the average total fertility in the BA (defined as a five-year average of births per women aged 15 through 50 that is centered on a census year) and the proportion of all women who are married at the time of the cross-section.[22] As the results will show, fertility rates should be treated with caution as a regressor. High fertility could exercise either a direct causal impact (through shortened birth intervals) or simply reflect limited breastfeeding. High infant mortality rates could also reduce the length of post-partum amenorrhea in those districts where breast feeding was more common, which could lead to shorter inter birth intervals (and higher fertility).

Both specifications include a control for population density, which is intended to account for differential access to health and child care services between the rural BAs that were actually part of a larger metropolitan area and those that were in isolated locations (such as in the

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[21] Unfortunately, comprehensive data on when small and mid-sized towns introduced sanitary sewers and centralized water supply systems are not available for the towns and rural districts in the data set, so that a direct test of a sanitary hypothesis was not possible.

[22] The fertility regressor is a weighted average of legitimate and illegitimate fertility, where the weights are the proportion of women who are married at the time of the cross-section. Although illegitimate children faced a higher mortality risk than children born to married mothers, the differential was not as great in Bavaria as in some other German states. What is less clear from published studies is how much this difference reflects the different circumstances to which illegitimate children are born, versus the idea that the illegitimate children were “unwanted” and thus subject to higher mortality chances by virtue of this status.This might argue for including the two kinds of fertility as separate regressors. We do not take this approach for two reasons. First, we do not have separate mortality data by legitimacy status. Second, given our instruments, we do not think it wise to estimate models with two endogenous variables. We did, however, estimate a version of the fixed-effects models reported below with separate controls for marital and non-marital fertility. The estimates for other regressors are nearly identical to what we report.

Bavarian Forest). BAs with a higher density were also more likely to have a small town or two that could have sufficient population to make providing improved water and sanitation services more cost efficient. The models also include the proportion of residents who were Catholic. Drawing on voting data for elections to the *Reichstag*, we divide votes into those for the conservative parties, the liberal parties, and the Social Democrats. The reference political party is the *Zentrum*, the Catholic party. The Catholic variable and the voting results proxy for potential cultural differences in attitudes towards and knowledge of methods of infant care.

Differences in economic circumstances could influence the decision of mothers to work and the need to be involved in fieldwork. Consider first influences on female labor force participation, which contemporary studies insisted affected the willingness of the mother to breastfeed her infant. These influences would include the real wage paid to female day laborers and employment in the textile industry. [23] The structure of the agricultural sector in a BA would also have bearing on how the mother would allocate her time across child-rearing and work on the farm. The reference case in our analysis was set as the share in a BA of very small parcels (under 2 hectares), which were below the threshold of a family farm. As noted above, small and medium-sized family farms of 2-5 hectares and 5-20 hectares, which were usually too small to support fulltime agricultural "servants," would rely more heavily on the labor of family members during peak periods of labor demand. A district with a high proportion of farms in these two categories would be expected to have higher infant mortality.

Higher real male wages (all other things being equal), should lead to better access to sanitation and housing. Along with the real wage paid day agricultural labor, the model includes employment in other secondary sector industries and mining. Workers in mining were generally

[23] The wages of day laborers are reported in the censuses of agriculture for 1883, 1895 and 1907.

very well paid; in addition, isolated mining villages typically offered women limited opportunities for employment. Both influences should lower infant mortality. Two year dummies account for pure trends in infant mortality from the base year of 1880. Column (1) of Tables 1 and 2 report the descriptive statistics for the data from the rural and urban BAs, respectively. Note that the variables capturing the farm size distribution are not included in the estimation of the infant mortality model for urban BAs.

Table 1 reports the regression results for the rural areas. The dependent variable is the infant mortality rate. We report the results of six specifications, including weighted and unweighted versions of OLS, fixed effects (FE), and IV with fixed effects. The OLS and FE estimates are in many ways quite different, suggesting that pulling out the unobserved heterogeneity among the BAs gets us much closer to the real impact of these regressors. This is especially true for the OLS model's very large estimates of the impact of fertility. In the rural Fixed Effects models, the impact of fertility on infant mortality remains, but the point estimate is one-third the size implied by the OLS specifications. In the urban Fixed Effects models, the impact of fertility is unaffected by the controls for geographic hetereogeneity.

The IV model tries to contend with the endogeneity of fertility. The causal effect of high fertility on mortality reflects constraints on household resources that means children born in high-fertility environments receive less attention and resources. In addition, high fertility is consistent with infant care practices (notably, breast feeding of very short duration) and the absence of family limitation that may increase infant mortality rates. As noted above, the causality in the FE specification could be reversed. In the presence of extended breast feeding, high infant mortality can lead to shorter birth intervals, which would produce higher fertility.[24]

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[24] Lactation is a mild contraceptive; if a child's death leads to the resumption of fecundability, then the death of one child raises probability of conception.

This concern leads us to report the IV specifications (which also have fixed effects). Our instruments for fertility are the proportion of wives under 30 and the square of this variable. Violation of the exclusion restriction here would require that the age structure of married women affect infant mortality directly. One might imagine that younger mothers would be less experienced and thus less able to care for a child, but few of the "young" mothers here would be less than 22 or 23 years old, and in any case in this context it seems unlikely that young married women mothers would be unable to find support from more experienced mothers. The IV models are not ideal; the first-stage F statistics are not as large as one would like. In general, it is difficult to find suitable instruments for these kinds of models, because variables likely to affect fertility (and thus be relevant) may not satisfy the exclusion restriction. But the IV and FE results are sufficiently similar to suggest that the bias in the OLS estimates reflects heterogeneity more than reverse causation.

In the preferred FE and IV specifications for rural BAs found in columns (4) through (7) of Table 1, higher total fertility increases infant mortality, but the impact is imprecisely estimated. A one standard deviation higher total fertility rate implies only a six percent increase in infant mortality. Denser areas have lower infant mortality, which might surprise those accustomed to thinking of mortality as higher in more crowded areas. We think this result reflects a relationship between population density and the ability to invest in public-health improvements. Poorer and thinly populated rural areas had stagnant or declining populations and were unable to develop better public health infrastructure, including improved sanitation and providing information to mothers about effective methods of care for infants. Of all the independent variables, the proportion Catholic is notable in the size of the coefficient. Note that the estimated impact is identified off of a change in the Catholic share of the population, most likely from in-migration. As it turns out, the largest increases in the share Catholic are found primarily in a minority of heavily Protestant districts, which are located some distance from the epicenter of high infant mortality in southern Bavaria. The voting behavior variables have little direct influence. Areas with significant textile employment had lower mortality. The sign on this variable is, *a priori*, ambiguous; to the extent textile firms employ women, they raise female incomes while at the same time raising the opportunity cost of caring for children. Here the former effect seems to dominate. The farm-size variables present some strong contrasts. As Roetzer hypothesized, small family farms of two to five hectares appear to have increased the demands on the mother's time for fieldwork and *increased* the risk of infant death. Again as is the case with the share Catholic, the impact is identified off of shifts in the farm size distribution from 1880 to 1910. The next largest group of farms had the opposite impact. As it turns out, as small farms were squeezed, larger middle-sized farms of up to 20 hectares (50 acres) expanded in size. The shift to much larger farm sizes in a high mortality district such as Dillingen in the Danubian plain would lower infant mortality by a predicted 13 percent. Across all rural specifications, the year effects are negative and precisely estimated. The reduction predicted solely by the year effects estimated for rural districts would account for half of the rural decline up to 1895 and over *four-fifths* of the decline by 1910.

The results for 38 Bavarian urban BAs, reported in Table 2, offer some striking contrasts. First note that the year effects contribute nothing towards the goal of accounting for the 37 percent decline in infant mortality in towns and cities. The number of observations here is much smaller than for the rural BAs and we acknowledge that our models may have more parameters than the data can bear.[25] Yet the instruments for the IV specifications appear to be considerably stronger than in the rural models reported in Table 1. In other respects, the variables in the urban do not do much to advance our understanding of influences on infant mortality. Estimated coefficients are either similar to our findings for the rural districts or are effectively zero. With the exception of the outsized coefficient on mining employment, the other variables in the regression have modest effects. Notably the share of Catholics has no appreciable impact in the towns (in contrast with rural Bavaria). Strong support for the (mostly non-clerical) conservative parties in the minority of Protestant towns is predictive of a modest reduction in infant mortality.

For the urban districts, the regression results point towards one key influence: fertility. In contrast with the rural models, the magnitude of the estimated coefficient on fertility is larger in the Fixed Effects and Instrumental Variable regressions estimated for urban districts than in the pooled models. In the case of urban areas, the endogeneity bias is negative. Factors not included in the regressions such as crowded housing that may prompt couples to restrict fertility may also contribute to higher infant mortality rates. The predicted influence of fertility on infant mortality is so strong that the decline in fertility of 27 percent from 1895 onwards predicts from 60 to 90 percent of the fall in infant mortality that we observe in Figure 2.

This look at the evidence from geographically aggregated data suggests that what prompted most of the modest infant mortality decline in rural areas were influences that were felt most strongly after 1900, but that found few correlates with the variables used in the regression analysis. In urban areas, the spatial and temporal correlation with changes in *fertility* suggest the need for a much closer look at potential links between various aspects of fertility behavior and

[25] These models drop the farm-size variables that appear in the rural specifications. One might think the mining variable should also be dropped. In fact, the mean of this variable in urban areas (.00267) is slightly more than half its rural value. The census reports workers by industry, not by what they actually do.

infant mortality. Fortunately, data for just such a detailed look exist for the city of Munich over a long time span: 1825 to 1910. Analysis of these data, which were collected as part of a project on demographic behavior in Munich during the long nineteenth century, is the focus of the next section of this paper.

Infant Mortality in Munich

Munich's economic and demographic development over the period 1825 to 1910 offers an unusual opportunity to analyze the potential influence of changes in sanitary provision and conditions that affected the health of the mother during an era of unprecedented economic and social change. At the start of the period, Munich was a city with a population of about 65,000. It was the *Haupt- und Residenzstadt* of the Wittelsbach monarchy, which had acquired territories to the north and west in Franconia and the Rhenish Palatinate. Its population grew at a modest rate of 1.1 percent per annum until 1850. Thereafter, the rate of population growth doubled to the time of the Franco-Prussian War (1870-1871). Over the period from 1871 up until 1910, the population growth was on the order of 3.5-4 percent per annum. As late as 1850, governmental functions and the military dominated the economy of the city. By 1910, it was the third-largest city of Germany (after Hamburg and Berlin) and it had developed into an industrial city.

Even as Munich's economic development closely tracked the experience of many other rapidly-growing German cities, its pattern of fertility and infant mortality was exceptional. Knodel (1974) summarizes what was well-known to contemporaries such as Mayr: southern Bavaria, including Munich, and northern Austria shared a pattern of very high rates of infant mortality and low rates of breast-feeding. For reasons that are not immediately obvious, there are indications that Munich's infant mortality rate rose from perhaps 350 per 1,000 births shortly after the end of the Napoleonic Wars to a maximum of 440 during a few years in the 1860s. (See

Figure 3). Both among Bavarian towns and among middle- and large-sized German cities, Munich's high infant mortality stood out for much of the remainder of the century. Its relative standing only improved during the decade or so prior to World War I. As was the case in rural Bavaria, high infant mortality rates were associated with very low rates of breast-feeding. Seidlmayer (1937) provides a summary of the studies conducted on the issue. In the 1860s, about three-quarters of infants were never breastfed. The share apparently rose to five-sixths by the 1880s. A comprehensive survey conducted in 1910 found that the share of never-breastfed infants had dropped to 40 percent. Nonetheless, by the third month of life, 80 percent of infants were being fed with cow's milk or cow's milk mixed with other foods (such as flour soup)(see Munich Statistical Office (1911)).

Even in the 19th century Munich was a destination for tourists and longer-term residents seeking language study or engagement with its lively cultural life. Salomon (1906, pp. 462-463) reports that successive cholera and typhoid epidemics during the middle of the nineteenth century raised awareness of the need for sanitary reform, which led to the completion of a central water supply system fed by springs in 1883 and the construction of a centralized sewer system that was begun in the mid-1880s. By 1893, the city had received permission to dump raw sewage directly into the Isar River, which led to the rapid installation of flush toilets and by about 1910, four-fifths of households had access to a flush toilet.

The economic structure of the city changed considerably over the long nineteenth century as well. The history of Bavaria suggests four sub-periods for the 90 years between the mid-1820s (when the individual-level data are first available) and 1910. The period prior to 1848 was one of modest economic change that ended with shortfalls in harvests, spikes in food prices and heightened political activity that ended in the abdication of Ludwig I. The first period of more rapid economic growth from 1850 until the late 1860s coincided with the gradual breakdown of legal restraints on business formation, the right of marriage and the right of settlement.[26] The granting of *Gewerbefreiheit* in 1868 was the most important step towards liberalizing the economy. The third period ended with the initiation of large-scale sanitary reform in the mid-1880s. The final period is one of even greater economic growth, in-migration and diversification of the population.

Data: The *Polizeimeldebögen* as a Source for Historical Demography

This study uses a sample of about 5,000 live births from a sample of 5,200 couples taken from police and civil registration records found in the City Archive of Munich.[27] The sample was collected from a compilation of several types of records maintained by the state police and local civilian authorities to keep track of the population and monitor the ability of household heads to contribute to the quartering of troops. Lupprian (1994) provides a comprehensive guide to this collection, which is known as the *Polizeimeldebögen* (PMB). Similar to population registers maintained in Belgian and Dutch localities, the source includes data on all members of the family (organized by head of the family). Unlike population registers, the Munich system was maintained as a collection of forms (*Bögen)* for individuals or husbands who were heads of families. After an individual's initial arrival in the city or coming of legal age, the form was filled out in a matter of a week or two and then filed.[28] For any event that was recorded

[26] Bavarian law distinguished between three kinds of individuals who may be living in a rural district or town: inhabitants (*Inwohner*), permanent residents (those with a *Heimatrecht*) and citizens (*Bürger*, who had the right to serve in city government). Only those in the latter two categories had the right to claim public assistance and exercise other rights within the commune of residence.
[27] The sample was collected as a stratified sequential sample, with oversampling of the marriages concluded prior to 1830. National Institute of Child Health and Human Development grant (R-01-HD29834) and Yale University provided financial support for the collection of the sample.
[28] It should be noted that one set of forms was maintained by the (state) Police who oversaw the registration of the population, and another set was maintained by city authorities. The forms used by city authorities were not used to register births and deaths until 1891. The oldest of the forms used by Police authorities, the *Familienbogen*, was

(including a change of address within the city), the form was retrieved from the storage area, updated and returned. The system was labor intensive, but it did allow for ready access to individual records and for the recording of much more information than would have been possible in a standard population registry system, which typically relied upon large bound folio volumes with limited space for each individual or household. Periodic checks by the police or by census enumerators identified those cases where individuals or families moved out of the city without reporting to the authorities.

Data consistency checks suggest that the recording of births and deaths began in 1825 for the city of Munich (and 1833 for the outlying districts of Au and Haidhausen) and continued until about 1910. The records were updated for other purposes as well, including the registration of a business, the purchase or sale of a house, the recording of tax payments and moves within the city.[29] Coding on the data entry forms used in collecting the sample included a date of the last notation in the records. Records for which there was uncertainty about whether the infant survived the first year of life have been excluded from the analysis. The source provides information on moves in and out of the city, periods during which the husband or wife was banned (*ausgewiesen*) from the city and periods of incarceration; this amount of detail allows for more accurate calculation of the inter birth interval.

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issued only for permanent residents and citizens of the city (those possessing *Heimatrecht* or Bürgerrecht). Fortunately, the collection contains the forms from two districts outside of the city walls (Au and Haidhausen) that were homes to workers and craftsmen who would have found it difficult to gain permanent legal status in Munich. These areas (and their registration records) were incorporated into the city in 1854. In 1868 the remaining residents of Munich were brought into the system with a major revision to Bavarian laws governing marriage and settlement.

[29] Most German cities of the time maintained a *Melderegister*, which was maintained both on the forms for individuals or heads of households found in the PMB collection as well as separate house lists for each dwelling list in the community. The data on class, capital and business taxes will be analyzed in further research.

Data checks reported in Brown, Guinnane et al. (1993) suggest that virtually all births were recorded and infant deaths were not under-counted. Sex ratios at birth were consistent with what was reported in official documents and the age pattern of infant deaths mirrors what is available from published sources. The main drawback of the data source is that stillborn infants were under-reported, which was the practice in most of southern Bavaria.[30] Note that the estimation in this paper includes only "legitimate" births.

Along with the names, religions and birthdates of family members, the records also include their civil status: whether born out of wedlock, born out of wedlock but subsequently legitimized (*pmsl*) or born within the marriage. The place of birth is almost always present for the husband and in most of the cases for the wife. In the cases where the husband remarried after the death of a wife (or a divorce), the name of the new wife along with her currently surviving children was recorded on the form. Figure 3, which shows the places of birth of the husbands in the sample, indicates that many were from the province of Upper Bavaria, of which Munich was also the capital, and the adjacent Danubian plain that reached into Swabia. A much smaller number were from outlying districts, including the Rhenish Palatinate (*Pfalz*) located to the west of the Rhine.

Occupational detail is exceptionally strong. Most heads of families have multiple records for their occupation. For example, the occupational information for those in the civil service includes the date and title for each new promotion. Occupations in the sample were coded according to the classification of the Imperial Statistical Office of occupations for the 1907 census of occupations, which divides labor force participants into three main classes (owners or

[30] See Mayr (1870) for a discussion of this issue. Still-births were often baptized after the fact and then recorded as both a birth and then a death. This practice led to an over-inflated recorded number of infant "deaths" during the first few days of life.

managers, technical or management personnel and wage workers). The classification used here identified four classes of wage workers, a class of salaried employees, owners of small shops and an upper class of both owners and high-level salaried individuals. The four groups of wage workers were day and unskilled laborers, semi-skilled workers, skilled workers and lower-level white collar workers. The salaried workers worked as middle-level management in the private sector and government. High-level officials such as judges, mayors, major department heads in the state or local bureaucracy, and so forth were grouped together with those in the liberal professions (lawyers, physicians, pharmacists) and owners of larger businesses. Finally, ownership of a small business or shop was common in Munich during the period of the study. These individuals were assigned to a separate group ranked above skilled workers.

To account for the occupational diversity found in the PMB source, two classification schemes were developed. The first classified an individual according to the lowest ranked occupation that he reported during his time in Munich. The second assigned the individual to a group on the basis of his highest-ranked occupation.[31] The occupational distributions evident in column (1) of Table 3 suggest that the forty percent of the births in the analysis occurred to women whose husband was at one time or another an unskilled worker. Another 36 percent were born into a family headed by a skilled worker. Comparisons of the sample with the available sources on the composition of occupations in Munich for the second half of the nineteenth century suggest that the sample follows the occupational distribution closely until the early 20th century, when the proportion of lower-skilled workers is under-represented in comparison with data from the occupational census.

[31] Since most individuals who held a job in group 2 (semi-skilled workers) usually found their way into a higher group, groups 1 and 2 were combined for the analyses that use the "maximum attained" classification.

The primary PMB data source also frequently recorded tax payments on earned income, income from fixed income securities and earnings of businesses. Typically a business owner who was taxed was exempt from the income tax. Strictly speaking, none of these taxes was an income tax. Instead, taxpayers were assigned to brackets and assessed a tax payment.[32] Nonetheless, the reported taxes were strongly correlated with income. They are used here to back out estimates of average annual income for over one-half of all of the couples in the sample and almost three-quarters of those who experienced a birth from 1858 onwards.[33]

The statistical analysis in this part of the study estimates the general relationship

(1) Prob(Infant Death)=f(environmental conditions, income, maternal/family attributes).

The analysis examines the impact of these influences on probability of that an infant born during the period period 1825-1910 died in infancy and includes over 4,000 live births. The specification of environmental conditions includes the share of parcels in Munich that were connected to the water supply system, which began operation in 1883 and rapidly expanded service to most of the city.[34] The other environmental variable of keen interest to observers in the late nineteenth century and during the first decades of the twentieth century was the average daytime temperature. Prausnitz (1901) noted that high summer temperatures were strongly associated with a rash of infant deaths. Known as the summer peak (*Sommergipfel*), this phenomenon attracted widespread attention as it became more common across the larger German

[32] Taxes on businesses were assessed on the basis of capital inputs and the number of employees.
[33] The average annual income estimates assume that business income was taxed at 2.1%, which is the estimate used in a discussion of Munich incomes from 1882 (See (1882)). Income was adjusted for price level changes using Desai (1968).
[34] Munich also began construction of an integrated sanitary sewer system in the 1880s. A court decision gave the city the right dump untreated raw sewage into the Isar River starting in late 1893, which led to the installation of flush toilets in perhaps 80 percent of the buildings by 1905. Results for the share connected to the sewer system and able to use flush toilets were similar to those for provision of water. Both variables are so highly correlated that a separate effect could not be estimated for each one of them.

cities during the 1870s and 1880s. Identifying the causal mechanism that linked elevated heat waves and infant deaths from gastro-intestinal disease remained an elusive goal even after a raft of studies that appeared in the medical and public health press. It *was* clear to observers that the risk of death for infants being breastfed was a fraction of the risk for those that had been weaned. The specification here includes the average monthly temperature during the infant's first full month of life.

Measures of income used in the study include occupational status (as discussed above), estimated income from recorded tax payments and whether or not the head of the house at one time owned a house (typically an apartment building) or a dwelling characteristic of the working class quarters outside of the old city walls, a *Herberge*. This kind of dwelling was a unit within a multi-unit structure that could be purchased for a fraction of the price of a house. It was typically found in a dilapidated older structure and most likely lacked one or more of the modern sanitary conveniences found in buildings of more recent construction. Nonetheless, ownership of a *Herberge* was a form of wealth.

The PMB data source allows for a full reconstitution of demographic events in the lives of the married couple, including births and deaths of all family members. An additional advantage of the source is that it records the migration history of the family to the extent that it reflected moves out of and into Munich. This information allows for ready identification of the survival status of the infant during the first year of life.[35] The source also includes variables that should reflect on two aspects of maternal health and a mother's ability to care for a newborn: the length of the prior birth interval and the survival status of the child born just prior to the index child.

[35] The analysis of infant mortality can thus exclude infants for whom the final survival status is unknown.

First, the shorter the inter birth interval, the more likely that an infant will be born prematurely. In addition, a series of short birth intervals could increase the risk for maternal depletion and or the introduction of fecal matter from younger siblings into the home environment. As Rutstein (2005) notes, a confounding influence on the length of the inter birth interval could be the death of a prior infant. If the infant were being breastfed, the interval could be shortened because of the cessation of postpartum amenorrhea so that there would be a spurious correlation between the birth interval length and the survival of the index child. The analysis here controls for the survival status of the infant(s) born immediately prior to the index child, but only if the index child was conceived after the death of its older sibling.[36] A third influence on the ability of the mother to care for the infant is the number of children currently alive in the household. Finally, the age of the mother is included to reflect the much higher risk of a problem pregnancy for women who give birth at a higher age.

Some observers noted differences in the impact of religious belief on the attention paid to infant health. For example, Hörger (1978, p. 27) argues that in rural Catholic Bavaria, neglect of the infant could actually serve as a form of after-the-fact birth control. Known as "*himmeln lassen*," the practice could also involve placing an infant with a wet nurse for a period that could last for several years should the infant survive its first few months. We also saw that Catholicism contributed positively to infant mortality in rural districts. The analysis here controls for the religion of the father.

The first column of Table 3 presents the mean and standard deviation of the variables used in the analysis of the PMB data. The average infant mortality for the 4,000 births analyzed in the

[36]See also Hobcraft, McDonald et al. (1983).

sample was 0.334 over the sample period, which extended from 1825 to 1910.[37] Slightly over one-half of births were male. The large proportion of Catholic fathers mirrors the religious composition of the Munich population during the period of analysis. Of greater interest are the characteristics of the families in the sample. The average number of siblings alive at the time of the index child's birth was over 2.6, which reflects the outcome of the high fertility-high mortality regime prevailing during much of the period. One-third of those born just prior to the index child's birth died in infancy prior to the conception of the index child. The average age of the mother was 32.8 years, which is reflective of the pattern for Munich as a whole. The average inter birth interval (preceding the index child) was about two years; over forty percent of birth intervals were eighteen months or under. By contrast Knodel and Hermalin (1984, Table 1) report that less than one-quarter of birth intervals were of such a short duration in the 14 German villages they studied. The PMB data bear out the expectation that the reported low rates of breast feeding would result in very short inter birth intervals.

The data on the economic status of husbands in the sample displays considerable variation. The average real income of about 2,000 Marks (given the buying power of 1913) would be consistent with an income of highly skilled workers during the first decade of the 20th century. The median of about 1,000 Marks was much closer to the annual earnings of semi-skilled workers. Overall, about 40 percent of the sample reported a *minimum* occupation that was either unskilled or semi-skilled and only ten percent reported a *minimum* in the top two categories. At the other extreme, perhaps 20 percent attained an occupation that could be assigned to the highest occupational grouping. The proportion reporting ownership of a house or *Herberge*

[37] We restricted the sample to births recorded for the first wife of the husband and excluded twins. We also included only those births for which we could calculate the inter birth interval with respect to the previous birth(s).

during the period that they appear in the PMB records is about 30 percent (when overlapping ownership is included). This share reflects the relatively high rates of ownership among the families tracked by the registration system up 1868, after which all residents of the city were included regardless of their legal status in the city. By 1890, the proportion of births to owners of houses or *Herberge* was about ten percent.

Figure 4 illustrates the ability of the data set to track the main contours of changes in infant mortality in Munich over the 90 years of analysis. Annual infant mortality data are not available for about 1825-1844 and again in the early 1850s. The data set captures average values through the late 1850s and again starting about 1880. The sample data also reflect the increase in infant mortality apparent in Munich as economic growth picks up in the 1850s, but not to the degree that it actually rose. The most likely source of the differential is the more restrictive coverage of the underlying data source until the late 1860s, which primarily included only the more established families living in Munich.[38]

Results of the Logit Analysis

Table 3 presents the analysis of influences whether or not an infant died during the first year of life for the two alternative definitions of social class in columns (2) through (5) and for the couples (with 2,150 births) for whom information on the average income of the family could be estimated (in columns (6) and (7)). Overall, the models correctly predicted about two-thirds of the actual outcomes in the sample. The marginal coefficients in columns (3) and (5), which are calculated at the sample means, help assess the relative importance of the key variables in predicting mortality outcomes. Consider first the role of individual and family characteristics. As

[38] Registration of the remainder of the population took place in large folio volumes known as the PKR. All residents found in the PKR were transferred to the PMB system during the changeover in the late 1860s.

is also evident from published statistics, male infants were about four percent more likely not too survive the first year of birth than females. Catholicism and sibship size had little bearing on the risk of infant death. A one standard deviation increase in the age of the mother raises the probability of an infant death by about five percent relative to the sample average infant mortality. Provided that extending breastfeeding by six months would have an equivalent impact on postpartum amenorrhea and lengthen inter birth intervals by that amount, the predicted reduction in the risk of an infant death would be about three deaths per 100 births, or seven percent of the sample average. That is one-third of the impact of the death of the index child's next oldest sibling (or siblings) in infancy.

Variation in environmental conditions could have an influence on infant mortality, but the contribution was also modest. Suppose that truly warm months registered an average temperature at or above 18˚ C, which is ten degrees above the sample average temperature. Since 1890, only about eight percent of summer months were that warm. Even assuming the marginal effect for the later period equaled about 0.005 (the sum of coefficient on Temperature with the interactive term), these hot months would raise infant mortality by about 15 percent. The predicted impact of installing the piped water supply system is large by comparison. The installation of centrally supplied, good quality water between 1883 and the mid-1900s, when it was completed, would lower predicted mortality by about seven deaths per 100 births, or 20 percent of the sample average.

Social-economic circumstances also influenced infant mortality during this period of Munich's history. The reference case in columns (2)-(5) is a female born to a Protestant or Jewish member of the highest income group (owners of larger businesses, top officials, doctors, lawyers, etc.). The impact of the class variable differs according to whether the husband was assigned to the highest class he attained, or to the lowest class. Those who may have at one point in their careers worked as a laborer, factory worker, helper or peddler had an infant mortality rate that was 20 to 22 per 100 higher than (or 2.2-2.3 times) the average for the group that started out and remained in the highest group. The group with lower class husbands constitutes about three-quarters of the couples in the sample. With the exception of middle management, the remaining occupations had infant mortality rates 15 to 18 per 100 higher than the highest-level group.

The results using the maximum occupational attainment of the husband reveal a similarly strong impact of status as a low-skilled or semi-skilled worker as well as a small businessman. In this case, the penalty is 8.7 to 10.6 deaths per 100, which is about 32 to 40 percent higher than the average for the 20 percent of households who at one time or another attained the highest class status.

Finally, the results reported in columns (6) and (7) underscore the importance of income for the survival prospects of an infant. Perhaps because income is a cleaner measure of access to better nutrition and housing, the influence of Catholicism reappears as a strong separate influence on infant mortality. The marginal effect of 0.077 means that the risk of an infant death was 25 percent higher among families headed by a Catholic. The impact of a prior infant death was similar. The results for warm temperatures were stronger and the impact of piped water was about the same as with the other specifications of social-economic standing.

Using percentiles in the distribution of estimated income by households offers one way to assess the steepness of the income-mortality gradient. Munich was a city of extremes in the income distribution. For the 650 households for whom an income estimate could be obtained, the

Gini coefficient would be 0.57.[39] A family with an estimated income at the first quartile would earn about 720 Marks; at the third quartile the earnings would be 1,580 Marks. An increase in income equivalent to the interquartile range would result in only a modest predicted reduction in infant mortality of three percent. Moving from the 10th (420 Marks) to the 90th percentile (3.4 thousand Marks) would have a predicted impact of an 11 percent reduction in infant mortality from the average value for the 10th percentile.

These results assume that the coefficients remained stable over the 90 years that the sample covers. The results also do not take note of the change in sample composition after the major revision to the settlement laws in the late 1860s. Table 4 reports results for the same occupational groupings used in Table 3, but the estimation allows for the coefficients on the dichotomous variables denoting the social class to vary. The interaction term for the second period indicates an overall decline in infant mortality of 3.6 per 100, which is a reduction of about 10 percent from the high rates of infant mortality prevailing in the late 1860s. The social class differentials evident in Table 3 are more pronounced in Table 4, particularly in the second period when the population was likely to be more hetereogenous. In the first period, all groups (with the exception of small businessmen) were disadvantaged when compared with the highest group, but only moderately so. For the results in columns (2) and (3), the differential ranged from one to five infant deaths per 100, which was a small fraction of the average of 35 deaths for the period. After 1868, a steeper mortality gradient emerges for all classes, so that the differential is now 14.1 per 100 for the unskilled and semiskilled workers, which more than cancels the gains observed overall. The differential was 7.4 to 9.1 for skilled workers and managers. The only group to gain ground in relative terms were small businessmen. The results in columns (3) and

[39] Among larger United States cities, only Atlanta has this high of a Gini coefficient. See Weinberg (2011, Table 6).

(4) of Table 4 tell a similar story. Recall that assigning a husband to the lowest group he ever worked in leads to much larger differentials across social classes. During the first period, infant mortality rates for families headed up by blue collar wage earners (unskilled, semi-skilled or skilled) were 15-21 deaths per 100 higher than for the most well-off in Munich. After 1868, even as the overall rate dropped about 15.5 per 100, the rates for the unskilled, semi-skilled, lower level white collar and skilled workers were 27 to 32.6 per 100 higher than for the best-off group (predicted at the sample means for all variables). Although clean and plentiful water supplies maintain their importance in this specification, the differentials across social classes seemed to have overwhelmed the gains experienced by all of the city from improved water supply.

Conclusions

This appraisal of what prompted high rates of infant mortality in Bavaria and Munich during the long nineteenth century provides support for the view common in the nineteenth and early twentieth centuries that low rates of breastfeeding (and early termination of breastfeeding) made major contributions. The results from the rural regressions and logit analysis of infant mortality in Munich provide some indirect and more direct evidence that improved sanitation (primarily high quality piped water) helped to reduce infant mortality, presumably by allowing the family to practice better hygiene that could protect the infant from water- or food-borne sources of gastro-enteritis. The reduction in infant mortality would have been about 17 percent of the rates prevailing in the early 1860s, which would be equivalent to one-third of the actual decline from 40 to 17 per 100 by 1910. The regressions on district-level data for rural Bavaria offer some support for the idea that living and working on a small family farm may have diverted a mother's time away from infant care and led to an early cessation of breastfeeding. The result may have been higher infant mortality. For urban areas, the regression results prompt a closer look at the links between high fertility and high rates of infant mortality.

The evidence on the adverse impact of short inter birth intervals on infant survival is consistent with that focus. One source of shortened inter birth intervals is again a lack of breastfeeding (or breastfeeding of short duration). The strong correlation of mortality rates with high summer temperatures is also indicative of low rates of breastfeeding. Finally, the importance of social class as an influence on infant mortality rose markedly as the nineteenth century wore on. By the turn of the century, mothers in households headed by a day laborer or helper in a factory faced a risk of death of an infant that was two or perhaps two and one-half times the risk faced by upper income mothers. Clearly the benefits of the reductions in infant mortality that did take place were distributed unevenly up until World War I.

These findings suggest three additional avenues for further research. The first is to look more closely at the influences on infant mortality in towns and rural districts using data from the 1860s using the data on farm size distribution, fertility, relative earnings and so forth that are available for this period of very high infant mortality. The second is to examine more closely what influenced infant survival over the first year of life using duration models of the individual-level data available for Munich. Some observers such as Seidlmayer (1937) and Roetzer (1913) have argued that breastfeeding was expanding in Munich just prior to World War I. A shift in the age pattern of infant deaths during the period of decline could signal changes in infant feeding practices, which may turn out to be important for the rapid progress that Munich made after 1900. Finally, some data are available to allow for a closer examination of the impact of unsatisfactory sanitary conditions on infant mortality and to gain a better understanding of the extent to which income guaranteed families access to much healthier housing and sanitary conditions.

Archival Source

Polizeimeldebögen (PMB) collection of the Munich City Archive

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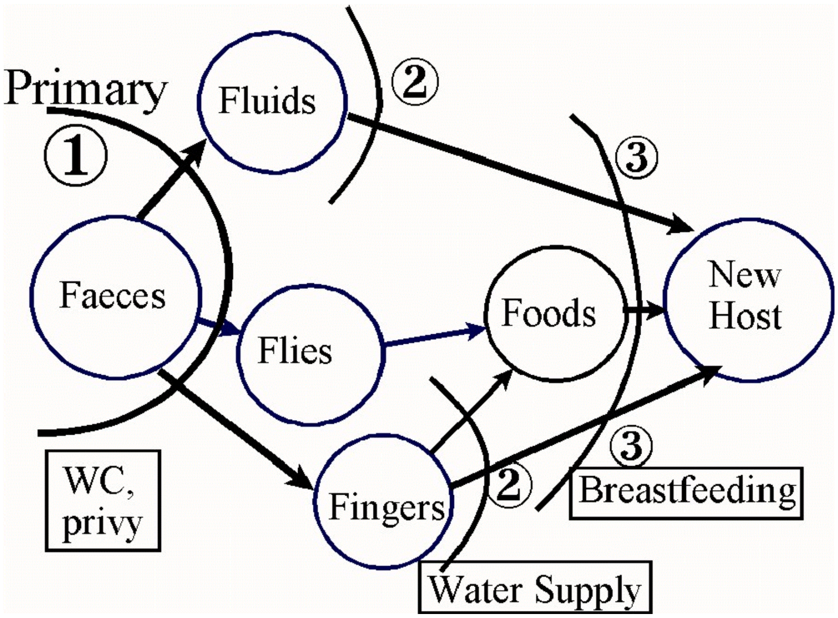
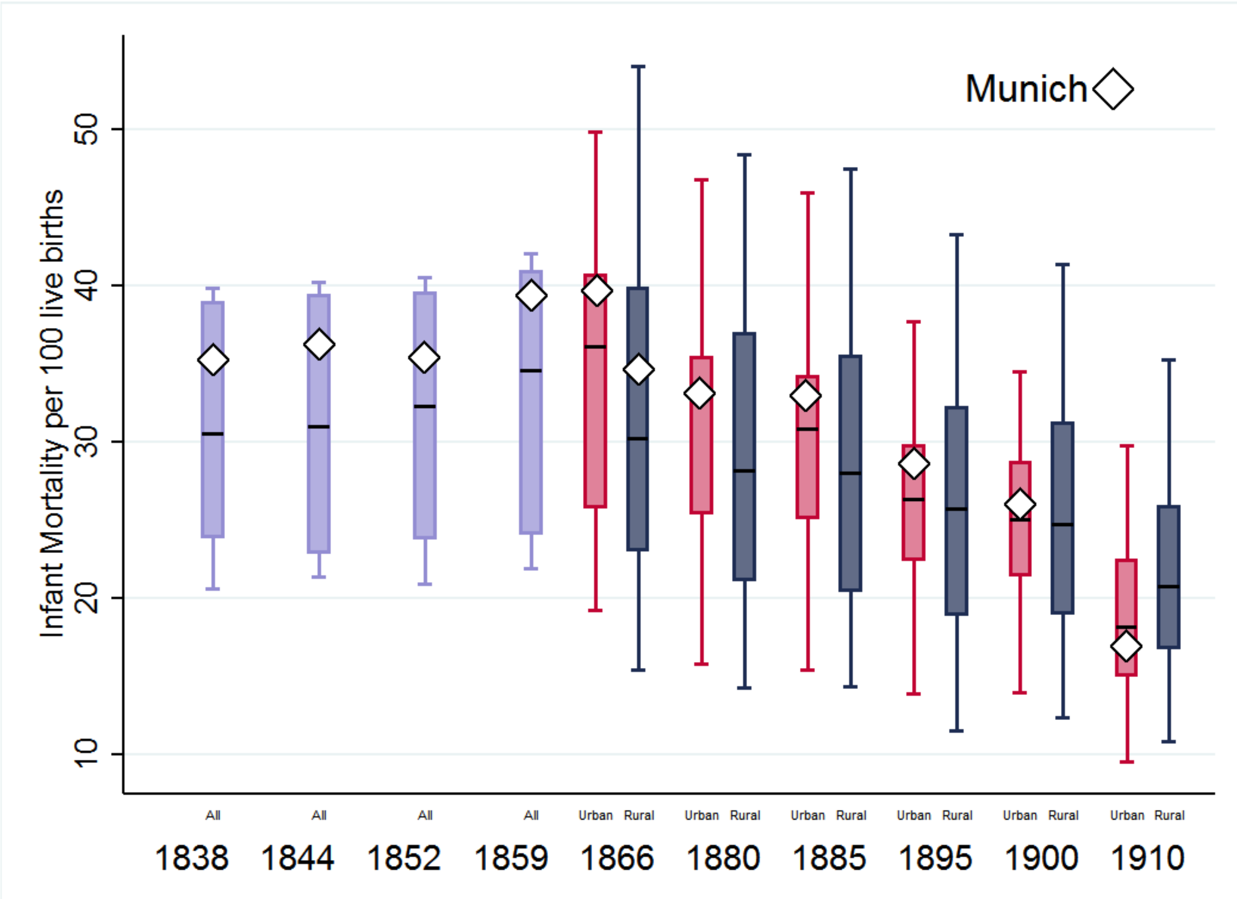
Figure 1: Paths for Transmission of Pathogens Causing Gastro-Intestinal Illness among Infants



Source: Adopted from Curtis, Cairncross et al. (2000).

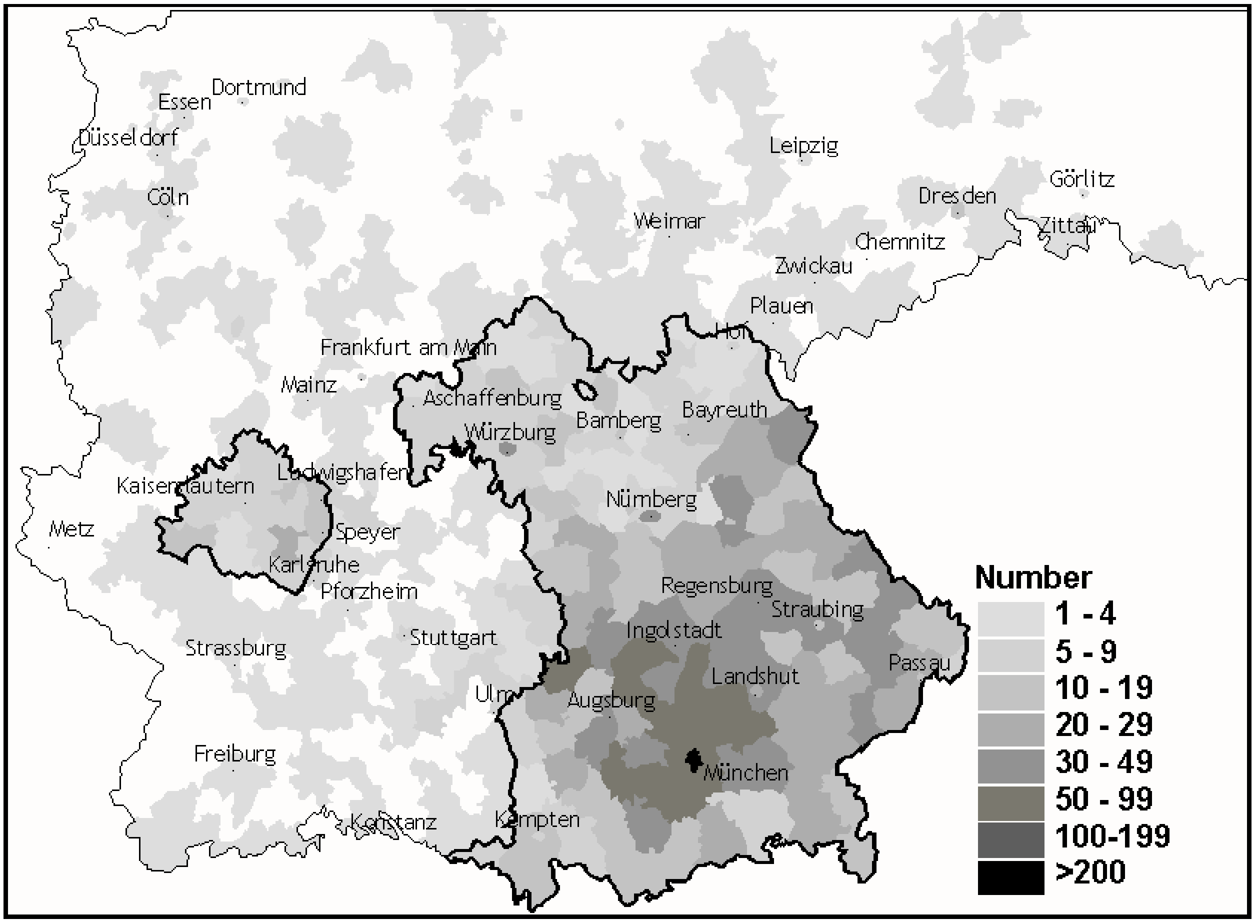
Figure 2: The Distribution of Infant Mortality in Urban and Rural Bavaria and Munich: 1838-1910



Source: *Beiträge zur Statistik Bayerns*, various issues and Mayr (1870).

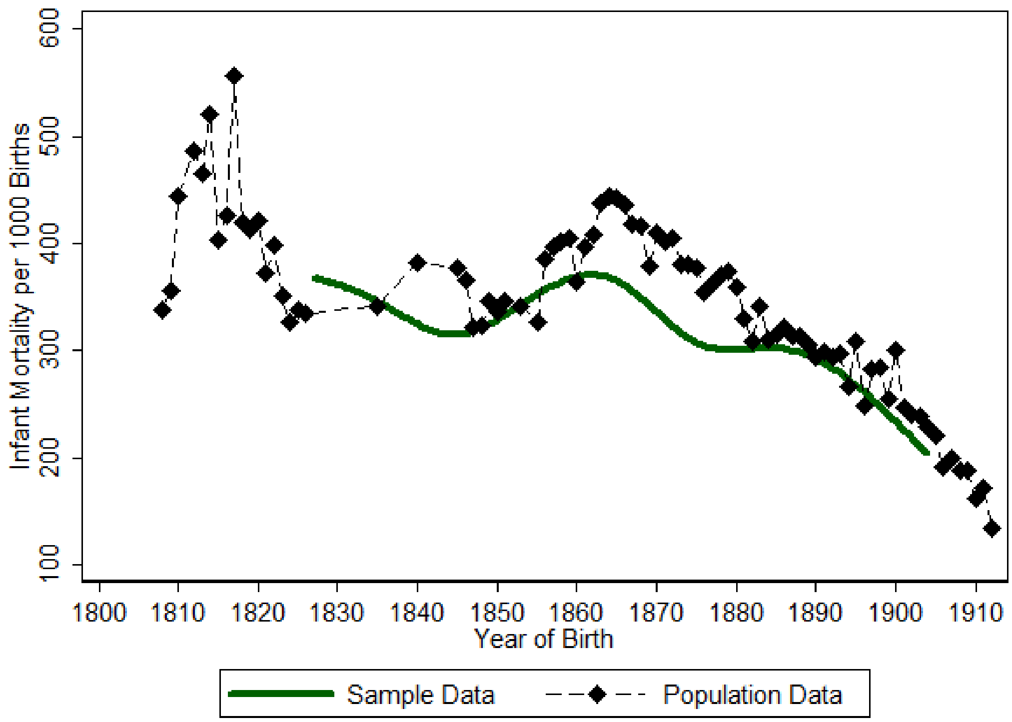
Notes: "All" refers to provinces of the Kingdom (Regierungsbezirke). Rural areas are *Bezirksämter* and urban areas are *Unabhängige Städte*. The years represent the following averages: 1838 (1835/1841). 1844 (1841/1846). 1852 (1849/1855). 1859 (1855/1862), 1866 (1862/1869), 1880 (1878/1882), 1885 (1883/1887), 1895 (1893/1897). 1900 (1898-1902), and 1910 (1908/1912).

Figure 3: The Birthplaces of Husbands in the Sample from the Polizeimeldebögen



Notes: The territory of the Kingdom of Bavaria is outlined in black. Birthplaces are recorded by counties (*Bezirksamt or Kreis*). The area to the west of present-day Bavaria is the Palatinate, which belonged to the Kingdom of Bavaria until after World War II.
Source: Sample from the Polizeimeldebögen.

Figure 4: Infant Mortality in the PMB Sample and in Munich



Notes: The sample data are smoothed with 10 bands and 17 points.

Source: For a discussion of the source of the PMB sample, please see the text. The municipal data are found in the *Mitteilungen* of the Munich Statistical Office.

Table 1: Influences on Rural Infant Mortality in Bavaria, 1880-1910

Variables	(1) Mean (s.d.)	(2) Pooled OLS Unweighted	(3) Pooled OLS Weighted	(4) OLS with Fixed Effects Unweighted	(5) OLS with Fixed Effects Weighted	(6) Instrumental Variable with Fixed Effects Unweighted	(7) Instrumental Variable with Fixed Effects Weighted
Total Fertility	0.155	2.118	2.090	0.718	0.718	0.260	0.525
	(0.0291)	(0.139)	(0.144)	(0.169)	(0.166)	(0.736)	(0.651)
Share Females aged 15-50 Married	0.496	-0.184	-0.152	0.256	0.230	0.376	0.280
	(0.0440)	(0.112)	(0.130)	(0.115)	(0.113)	(0.200)	(0.177)
Population density	0.603	0.0176	0.0151	-0.0929	-0.0702	-0.0944	-0.0702
(persons per ha.)	(0.193)	(0.0136)	(0.0157)	(0.0334)	(0.0327)	(0.0274)	(0.0253)
Cultural/attitudes							
Share Catholic	0.780	-0.0293	-0.0269	0.704	0.713	0.780	0.752
	(0.318)	(0.0135)	(0.0148)	(0.162)	(0.183)	(0.217)	(0.222)
Conservative	0.0453	0.0202	0.0218	0.0197	0.0290	0.0232	0.0296
	(0.119)	(0.0205)	(0.0214)	(0.0162)	(0.0175)	(0.0197)	(0.0200)
Liberal	0.202	-0.0697	-0.0730	0.00225	0.000494	0.0139	0.00594
	(0.205)	(0.0152)	(0.0159)	(0.0127)	(0.0134)	(0.0228)	(0.0228)
Socialist (SPD)	0.102	0.0110	-0.00603	0.0489	0.0370	0.0478	0.0373
	(0.121)	(0.0282)	(0.0312)	(0.0337)	(0.0372)	(0.0281)	(0.0277)
Wages/ Employment							
Real Male Wage	1.511	0.0369	0.0322	0.00294	-0.000610	0.0123	0.00365
	(0.250)	(0.0157)	(0.0154)	(0.0190)	(0.0193)	(0.0197)	(0.0187)
Real Female Wage	1.155	0.0440	0.0450	0.0116	0.0140	0.0105	0.0135
	(0.194)	(0.0141)	(0.0153)	(0.0177)	(0.0181)	(0.0121)	(0.0117)
Textile	0.0213	-0.123	-0.0945	-0.208	-0.224	-0.253	-0.243
	(0.0537)	(0.0414)	(0.0492)	(0.159)	(0.180)	(0.175)	(0.179)
Other industrial	0.214	-0.0767	-0.0643	0.0209	0.00283	0.0247	0.00644
	(0.0752)	(0.0413)	(0.0456)	(0.0642)	(0.0734)	(0.0514)	(0.0540)
Mining	0.00463	-0.243	-0.321	-0.132	-0.141	-0.131	-0.141
	(0.0188)	(0.110)	(0.114)	(0.156)	(0.163)	(0.164)	(0.167)
Farm Size Distribution							
2 to 5 ha.	0.2481	0.0171	0.0239	0.212	0.188	0.264	0.209
	(0.04399)	(0.0618)	(0.0667)	(0.0815)	(0.0874)	(0.110)	(0.0995)
5to 20 ha.	0.3628	0.0520	0.0483	-0.210	-0.246	-0.216	-0.245
	(0.07697)	(0.0332)	(0.0365)	(0.0709)	(0.0845)	(0.0676)	(0.0677)
20 to 100 ha.	0.07913	0.201	0.206	0.101	0.0945	0.101	0.0956
	(0.5249)	(0.0721)	(0.0773)	(0.0452)	(0.0645)	(0.0679)	(0.0758)
Over 100 ha.	0.000989	5.189	6.586	-0.145	-0.625	0.412	-0.432
	(0.00136)	(1.865)	(1.978)	(2.357)	(2.569)	(2.238)	(2.072)
Year is 1895	0.336	-0.0259	-0.0243	-0.0161	-0.0151	-0.0190	-0.0165
	(0.473)	(0.00635)	(0.00717)	(0.00637)	(0.00642)	(0.00667)	(0.00663)
Year is 1910	0.333	-0.0583	-0.0564	-0.0626	-0.0627	-0.0745	-0.0681

	(0.472)	(0.00747)	(0.00788)	(0.00847)	(0.00880)	(0.0203)	(0.0195)
Constant		-0.0631	-0.0726	-0.462	-0.450		
		(0.0596)	(0.0699)	(0.132)	(0.148)		
Observations		411	411	411	411	411	411
Adjusted R^2		0.794	0.796	0.830	0.839	0.727	0.750
F		105.6	97.48	61.52	65.56	68.49	76.06
Number of BAs				138	138	138	138
R^2 within				0.837	0.846		
R^2 between				0.298	0.296		
R^2 overall				0.292	0.291		

Notes: The dependent variable is the infant mortality rate (deaths per births), which average 0.254 during the period of analysis. The unit of observation is a rural district (*Bezirksamt*). The base case for farm sizes is farms less than 2 ha. The base case for the year is 1880. The instrument for total fertility is the share of married females under 30 and that share squared. The weight used in the regression is the inverse of the average number of births in the BA. Textile, other industrial and mining refer to the share of employment in the town. The base political party is the Catholic Center.

Source: Results of OLS and IV regression. The instrument for total fertility is the share of women younger than 30 years old and its square. The weight for each observation is the average number of births per town.

Table 2: Influences on Urban Infant Mortality in Bavaria, 1880-1910

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Pooled OLS		OLS with Fixed Effects		Instrumental Variabl with Fixed Effects	
Variable	Mean (s.d.)	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weight
Total Fertility	0.113	1.256	1.040	0.920	1.633	1.837	3.106
	(0.0228)	(0.444)	(0.410)	(0.387)	(0.390)	(0.772)	(0.511
Share Females aged 15-50 Married	0.462	0.0273	0.284	0.330	0.342	0.147	-0.044
	(0.0507)	(0.171)	(0.181)	(0.188)	(0.180)	(0.220)	(0.254
Population density (persons per ha.)	28.10	8.77e-06	-0.000100	0.000117	-4.60e-05	0.000124	8.71e-
	(49.48)	(0.000128)	(7.36e-05)	(0.000120)	(0.000122)	(0.000162)	(9.54e-
Cultural/attitudes							
Share Catholic	0.632	0.0933	0.131	-0.0662	0.0222	-0.0633	0.087
	(0.330)	(0.0285)	(0.0349)	(0.147)	(0.197)	(0.115)	(0.136
Conservative	0.0557	0.0214	-0.0202	-0.129	-0.154	-0.145	-0.14
	(0.114)	(0.0496)	(0.0560)	(0.0690)	(0.0794)	(0.0615)	(0.075
Liberal	0.258	-0.0745	-0.0863	-0.0321	-0.0654	-0.0496	-0.055
	(0.222)	(0.0296)	(0.0375)	(0.0509)	(0.0483)	(0.0437)	(0.036
Socialist (SPD)	0.127	-0.0279	0.0233	0.0330	-0.0765	0.0250	-0.018
	(0.150)	(0.0416)	(0.0327)	(0.0821)	(0.0537)	(0.0674)	(0.057
Wages/ Employment							
Real Male Wage	1.842	0.0228	0.0266	0.0419	0.0534	0.0382	0.076
	(0.361)	(0.0434)	(0.0560)	(0.0357)	(0.0623)	(0.0346)	(0.050
Real Female Wage	1.274	-0.0590	-0.0286	-0.0505	-0.0346	-0.0535	-0.046
	(0.229)	(0.0357)	(0.0460)	(0.0320)	(0.0406)	(0.0304)	(0.042
Textile	0.0320	0.126	0.160	0.376	0.415	0.348	0.316
	(0.0526)	(0.0975)	(0.0982)	(0.196)	(0.289)	(0.202)	(0.276
Other industrial	0.406	0.163	0.300	0.0110	0.0155	-0.0720	-0.14
	(0.0886)	(0.0713)	(0.0883)	(0.167)	(0.212)	(0.144)	(0.139
Mining	0.00257	-1.464	-1.926	-0.443	-2.259	-0.483	-3.42
	(0.00971)	(0.400)	(0.467)	(0.677)	(0.851)	(0.937)	(1.085
Year is 1895	0.336	-0.0323	-0.0462	-0.0251	-0.0134	-0.0189	-0.011
	(0.475)	(0.0134)	(0.00961)	(0.0142)	(0.0168)	(0.0131)	(0.015
Year is 1910	0.336	-0.0519	-0.0990	-0.0742	-0.0480	-0.0365	0.004
	(0.475)	(0.0241)	(0.0244)	(0.0260)	(0.0292)	(0.0367)	(0.031
Constant		0.101	-0.113	0.103	-0.0455		
		(0.0744)	(0.0870)	(0.129)	(0.149)		
Observations		113	113	113	113	113	113
Adjusted R^2		0.651	0.776	0.855	0.923	0.740	0.829
F		29.45	68.65	37.65	245.8	27.03	44.62

Number of Towns	38	38	38	38
R^2 within	0.873	0.933		
R^2 between	0.0152	0.251		
R^2 overall	0.176	0.488		

Notes: The dependent variable is the infant mortality rate (deaths per births), which averaged 0.252 during the period of analysis. The unit of observation is a town district (*Unabhängige Stadt*). The base case for the year is 1880 and the base political party is the Catholic Center. The weight used in the regression is the inverse of the average number of births in the town. Textile, other industrial and mining refer to the share of employment in the town. *Source*: Results of OLS and IV regression. The instrument for total fertility is the share of women younger than 30 years old and its square. The weight for each observation is the average number of births per town.

Table 3: Influences on Infant Mortality in Munich: 1825-1911

Variables	Mean (s.d.)	Social Class Grouping: Assigned to Highest Class		Social Class Grouping: Assigned to Lowest Class		Average Income	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Male	0.519	0.173	0.0379	0.167	0.0366	0.207	0.0435
	(0.500)	(0.0656)		(0.0658)		(0.0952)	
Family/maternal characteristics							
Husband is Catholic	0.886	0.193	0.0412	0.143	0.0307	0.392	0.0772
	(0.318)	(0.146)		(0.145)		(0.196)	
Number of Siblings	2.614	-0.0369	-0.00812	-0.0374	-0.00821	-0.0179	-0.00378
	(1.835)	(0.0245)		(0.0242)		(0.0352)	
Previous child died as an infant	0.326	0.315	0.0706	0.297	0.0662	0.378	0.0816
	(0.469)	(0.0749)		(0.0753)		(0.105)	
Inter birth interval	2.035	-0.215	-0.0473	-0.209	-0.0459	-0.200	-0.0422
	(1.241)	(0.0381)		(0.0385)		(0.0549)	
Age of mother	32.827	0.0142	0.00312	0.0117	0.00256	0.0166	0.00349
	(5.763)	(0.00709)		(0.00716)		(0.0103)	
Environmental							
Share of houses with piped water	0.260	-0.347	-0.0763	-0.350	-0.0769	-0.334	-0.0704
	(0.399)	(0.132)		(0.130)		(0.128)	
Temperature (in ˚C)	7.660	0.0121	0.00267	0.0135	0.00296	0.0185	0.0039
	(7.352)	(0.00650)		(0.00655)		(0.00662)	
Temperature X Period (1869-1910)	3.506	0.0110	0.00242	0.0102	0.00224		
	(6.317)	(0.00946)		(0.00950)			
Socio-Economic							
Average real income (in 1,000 Marks of 1913)	2.095					-0.0566	-0.0119
	(5.24)					(0.0164)	
Unskilled and Semi-Skilled†	0.343	0.378	0.0865	0.892	0.202		
	(0.475)	(0.145)		(0.238)			
Semi-Skilled	0.0661			0.914	0.219		
	(0.249)			(0.270)			

Lower level white collar	0.0770	0.127	0.0285	0.674	0.159		
	(0.267)	(0.158)		(0.254)			
Skilled	0.357	0.278	0.0619	0.798	0.180		
	(0.479)	(0.115)		(0.235)			
Small business	0.0558	0.458	0.106	0.727	0.173		
	(0.229)	(0.136)		(0.263)			
Middle Management	0.0555	0.205	0.0464	0.289	0.0660		
	(0.229)	(0.156)		(0.295)			
Own a house	0.265	-0.0808	-0.0176	-0.0996	-0.0217	-0.0989	-0.0206
	(0.441)	(0.0978)		(0.0937)		(0.136)	
Own a *Herberge*	0.0785	-0.0198	-0.00434	-0.0827	-0.0179	-0.132	-0.0272
	(0.269)	(0.131)		(0.132)		(0.209)	
Period: (1869-1910)	0.471	-0.104	-0.0229	-0.153	-0.0336		
	(0.499)	(0.125)		(0.124)			
Constant		-0.876		-1.308		-0.918	
		(0.188)		(0.264)		(0.258)	
Observations		4,053		4,053		2,150	
Log-likelihood Function		-2507		-2500		-1290	
Share correctly classified		0.66		0.66		0.68	
Pseudo R^2		0.0287		0.0313		0.0349	

†Only unskilled for "Lowest Class."

Notes: The dependent variable is infant mortality, which averaged 0.334 during the sample period of 1825-1911. The class assignment refers to whether or not the husband was assigned to the highest or lowest social grouping based upon the occupations reported in the PMB source. The base case in columns (2)-(7) is the highest social class (owners of businesses, liberal professions, high-level managers and officials). The coefficients reported in columns (3), (5) and (7) are the marginal effects for the variable calculated at the sample means.

Source: Results of logistic estimation with standard errors clustered at the family level. The estimation includes only infants born in wedlock to the first wife of the husband. Twins are excluded from the estimation.

Table 4: The Growing Importance of Social Class Grouping for Infant Mortality: 1825-1910

	Assigned to Highest Class		Assigned to Lowest Class	
Variable	(1)	(2)	(3)	(4)
Male	0.177	0.0389	0.173	0.0378
	(0.0660)		(0.0658)	
Family/maternal characteristics				
Husband is Catholic	0.176	0.0378	0.130	0.0281
	(0.148)		(0.146)	
Number of Siblings	-0.0346	-0.00760	-0.0384	-0.00842
	(0.0240)		(0.0244)	
Previous child died as an infant	0.308	0.0688	0.293	0.0654
	(0.0750)		(0.0757)	
Inter birth interval	-0.213	-0.0469	-0.208	-0.0457
	(0.0381)		(0.0382)	
Age of mother	0.0136	0.00299	0.0119	0.00262
	(0.00711)		(0.00719)	
Environmental				
Share of houses with piped water	-0.369	-0.0811	-0.361	-0.0792
	(0.133)		(0.132)	
Temperature (in ˚C)	0.0122	0.00269	0.0135	0.00296
	(0.00649)		(0.00653)	
Temperature X Period (1869-1910)	0.0108	0.00238	0.0109	0.00239
	(0.00945)		(0.00951)	
Social Class: 1825-1868				
Unskilled and Semi-Skilled†	0.213	0.0482	0.635	0.148
	(0.186)		(0.310)	
Semi-Skilled			0.874	0.210
			(0.369)	
Lower level white collar	0.0951	0.0212	0.455	0.106
	(0.206)		(0.325)	
Skilled	0.239	0.0539	0.673	0.156
	(0.151)		(0.305)	
Small business	0.646	0.153	0.732	0.175
	(0.161)		(0.337)	
Middle Management	0.0470	0.0104	0.0996	0.0222
	(0.222)		(0.369)	
Social Class: 1869-1910				
Unskilled and Semi-Skilled†	0.598	0.141	1.384	0.326
	(0.208)		(0.365)	

Semi-Skilled			1.254	0.302
			(0.400)	
Lower level white collar	0.165	0.0373	1.215	0.293
	(0.231)		(0.396)	
Skilled	0.327	0.0743	1.158	0.275
	(0.162)		(0.366)	
Small business	0.251	0.0571	0.873	0.210
	(0.222)		(0.422)	
Middle Management	0.395	0.0915	0.816	0.196
	(0.206)		(0.477)	
Own a house	-0.105	-0.0229	-0.0848	-0.0185
	(0.0977)		(0.0937)	
Own a *Herberge*	0.0187	0.00412	-0.0340	-0.00743
	(0.133)		(0.136)	
Period: (1869-1910)	-0.166	-0.0364	-0.718	-0.155
	(0.201)		(0.474)	
Constant	-0.833		-1.151	
	(0.201)		(0.316)	
Observations	4,053	4,053	4,053	
Log-Likelihood Function	-2502		-2497	
Share correctly classified	0.67		0.66	
Pseudo R^2	0.0308		0.0328	

†Only unskilled for "Lowest Class" approach.
Notes: The dependent variable is infant mortality, which averaged 0.334 during the sample period of 1825-1911. The class assignment refers to whether or not the husband was assigned to the highest or lowest social grouping based upon the occupations reported in the PMB source. The base case in columns (2)-(7) is the highest social class (owners of businesses, liberal professions, high-level managers and officials). The coefficients reported in columns (3), (5) and (7) are the marginal effects for the variable calculated at the sample means.
Source: Results of logistic estimation with standard errors clustered at the family level. The estimation includes only infants born in wedlock to the first wife of the husband. Twins are excluded from the estimation.