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"Can Breast Feeding Help You in Later Life? Evidence from German Military Heights in the Early 20th Century"*

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Abstract

Considerable literature exists on the benefits of breast feeding on the health and survival of infants and young children, but there is less on the effects on later life outcomes. One such measure of health and well-being that has received attention in the historical literature is terminal adult stature. Information on height is rather widely available; however, it is much more difficult to obtain data on breast feeding. One country that does have such information is Imperial Germany (1871–1919). A number of physicians and local health officials collected information on the incidence and duration of breast feeding early in the 20th century, particularly because of concern about the unusually high infant mortality rates in parts of Germany. Hallie Kintner has surveyed the published results of these studies. The information on the prevalence of breast feeding for the period 1903/10 has been inputted into a database of demographic and economic variables for the counties (Regierungsbezirke) of Germany (1850–1939). There are also published data on heights of military recruits from the Imperial German military forces in 1906. These can be linked to areas in the database and related to breast feeding practices and infant mortality both contemporaneously and approximately 20 years previous to 1906. Results indicate a significant effect of infant feeding practices on later life outcomes operating through infant health conditions, proxied by the infant mortality rate.

INTRODUCTION

Considerable literature exists on the benefits of breast feeding on the health and survival of infants and young children (Menken and Randall, 1996; Wolpin, 1997, pp. 535–540; Kintner, 1987; Woodbury, 1926, ch. V; Knodel, 1977). There is less on its effects on later life outcomes (Barker, 1992, 1994). One such measure of health and well-being that has received attention in the historical literature is terminal adult stature (see, for example, Tanner, 1981; Fogel, 1986, 1993; Komlos, 1994, 1995a, 1995b; Komlos and Baten, 1998; Steckel, 1983, 1995; Steckel and Floud, 1997). Such information is rather widely available.

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It is much more difficult to obtain data on breast feeding. One county that does have such information, on a limited basis, is Imperial Germany (1871–1919). A number of physicians and local health officials collected information on the incidence and duration of breast feeding early in the 20th century, particularly because of concern about the unusually high infant mortality rates in parts of Germany (Knodel and van de Walle, 1967). Hallie Kintner (1985 1987) has surveyed the published results of these studies. The information has been inputted into a database of demographic and economic variables for the counties (Regierungsbezirke) of Germany (1850–1939), which has been used for the study of the mortality transition in Germany (Haines and Kintner, 2000).¹

There are also some published data on heights of soldiers from the Imperial German military forces in 1906 (Evert, 1908). These can be linked to areas in the database and related to breast feeding practices and infant and childhood mortality concurrently and also approximately 20 years previous to the date of military induction. In this paper we look at early childhood mortality as well as infant mortality because life tables were estimated for most of the Regierungsbezirke. We also present income estimates in order to examine the effect of that variable on heights and infant and childhood mortality in the late 19th and early 20th centuries.

There is now a literature on the effects of early life experience on the later life outcome, such as terminal height, longevity, and overall health. (See, for example, Martorell, 1985; Martorell and Habicht, 1986; Fogel, 1993; Steckel, 1995; Lee, 2003; Barker, 1992, 1994.) The current thinking is that conditions of nutrition and disease loading in about the first three years of life can have permanent effects on human growth and development and later health. There is a competing view that "catch-up" is possible, such as that observed among slave children in the antebellum South in the United States (Steckel, 1986). It is also the case that the unfavorable or favorable conditions that prevailed in early life very often persist into adolescence and adulthood.

DATA

Imperial Germany (1871–1919) constitutes a good case study because of its high quality published historical demographic, economic, and social statistics. Knodel noted that "censuses and vital registration were virtually complete and accurate in their coverage by the 1860s" (Knodel, 1974, p. 30). Basic information about mortality conditions, which has long been known about some other European countries, has been less available and complete for Germany since the 25 state statistical offices published much of the material separately. These state statistical offices retained considerable autonomy even after creation of the Statistisches Reichsamt (Imperial Statistical Office) with the founding of the German Empire in 1871, although efforts to standardize the type, detail, coverage, and quality of statistics were reasonably successful. Thus Germany, which had a federal governance structure a bit analogous to that in the United States, solved its statistical collection and standardization problems more quickly than did the United States, which had complete census coverage from 1790 onwards but complete registration of births and deaths only from 1933.

Over this period, Germany undertook frequent censuses. Enumerations were made in 1871 and 1875 and every five years thereafter until 1910. With the exception of 1895 and 1905, detailed census population age and sex structures were published in the relevant geographic coverage for the counties of Germany (i.e., the Regierungsbezirk in Prussia or its equivalent in other lands) by the Imperial Statistical Office. The principal source is the Statistik des deutschen Reichs. The Imperial Statistical Office also reported annual births, stillbirths, and deaths by

¹The database will be deposited at the Inter-University Consortium for Political and Social Research. A copy may be obtained from Michael Haines.

sex from 1872 onward, although, as mentioned, deaths by age and sex (including infant deaths) were generally published only by the state statistical offices. The most important of these was the Royal Prussian Statistical Office (Koeniglichen Preussischen Statistischen Landesamts), whose principal source publication was the Preussische Statistik. The Prussian data tended to be the best in terms of coverage.

The creation of the German Empire after the Franco-Prussian War also coincides with the sustained mortality decline and with improved statistical coverage. The crude death rate declined from 28.9 per 1000 in 1871 to 16.7 in 1910, while the expectation of life at birth (for both sexes combined) rose from 37.0 in 1875 to 48.8 years by 1910. The infant mortality rate fell from 246 infant deaths per 1000 live births in 1869/73 to 170 in 1908/12 (Haines and Kintner, 2000, Table 3 & Table 4). Despite its rapid economic development prior to World War I, Germany was still, however, one of the nations with high mortality and especially high infant mortality. Compare, for example, the infant mortality rates for some other nations for the period 1908/12: Sweden, 75; Norway, 70; England and Wales, 112; the Netherlands, 112; Switzerland, 109; France, 123 (Mitchell, 1998, Table A7).

There were also large regional differences within Germany. For example, the infant mortality rate in 1875/80 varied from 383 in Schwaben (southern Bavaria) to 114 in Aurich (in northwestern Prussia), a difference as large as that between contemporary more and less developed nations.² There was some convergence over time. For example, the coefficient of variation of the infant mortality rate across the regions of Germany fell from .3274 in 1862/66 to .2449 in 1896/1900, but the level of dispersion stabilized there before declining again before World War II. The seven regions of Germany that are used in the analysis and are based on the original categorization of Knodel (1974, pp. 15–19). They were, in turn, based on the 1925 Census of Weimar Germany, with the exception that the Eastern Region was separated from the East Central Region because it had a significant population that was not ethnically or linguistically German. Most of these non-Germans were Polish. Although the choice of regional allocation of Regierungsbezirke was not clarified in the official publications, it was likely based on "mix of natural, historical, and cultural boundaries" (Knodel, 1974, p. 17). Dummy variables based on region do possess substantial explanatory power, however. For example, simply knowing the region of the Regierungsbezirk accounted for 49% of the variation in the infant mortality rate in 1871 and 48% in 1910 (Haines and Kintner, 2000, Table 6).

The data base includes a number of social, economic, and demographic variables. These include the Coale indices of overall fertility, marital fertility, non-marital fertility, and nuptiality (Coale and Watkins, 1986, Appendix B); information on live- and stillbirths; measures of mortality, including the crude death rate, the infant mortality rate, expectations of life at various ages, and the various measures from life tables constructed for the geographic units of Germany; the population size, area, density, growth rate, and percent urbanized (percent in urban areas of 2,000 and over, 20,000 and over, and 100,000 and over); estimated net intercensal migration; the percentage of the population in various religious denominations (Lutheran, Roman Catholic, Reformed, Jewish); the percentage of the population speaking a non-German language, most importantly Polish; the sex ratio (by age); estimates of income in the geographic units (see Appendix A); various measures of labor force activity and economic composition from the Berufszählungen (occupational censuses) of 1882, 1895, 1907, and 1925; the information on breast feeding (Kintner, 1985); and the published data on the heights of non-

²On the eve of World War I, the differentials were still very large: ranging from 265 in Niederbayern (Bavaria) to 94 in Aurich and 99 in Kassel (central western Germany) in 1911/14. Similarly, there were substantial rural-urban differences within regions which diminished over time (Knodel, 1974, Appendix 4).

commissioned officers, one year volunteers, and enlisted men in the German military (both army and navy) in 1906 (Evert, 1908). For a list of the variables used, see Table 1.

INFANT MORTALITY, BREAST FEEDING, AND STATURE

Earlier work on the United States and other countries has established a statistical relationship between adult stature and conditions in the area of birth of male military recruits. Using data from individual native white recruits to the Union Army during the American Civil War (1861–65), Haines, Craig, and Weiss (2003) found that the heights of recruits born during the years 1838–1842 were negatively affected by urbanization, local mortality conditions, and access to water and/or rail transportation in the recruits' counties of birth, while heights were positively affected by the extent of production of surplus calories and protein in the agricultural sector, which was a proxy for nutritional status early in life. (See also Craig and Weiss, 1998.) Similar results were found for Union Army recruits just from New York State (Haines, 1998). Data for states and county groups were available for the heights and weights of white male American recruits to the U.S. Army during World War I (1917–18). The heights and body mass index (BMI or kilograms of weight per meters of height squared) for the recruits were related to their birth states and 155 county groups in 1900 and 1910 (Haines and Steckel, 2000). They found that urbanization and mortality had a strong negative relationship with average height and BMI. For Germany, Twarog (1997) analyzed height data for military recruits from Wuerttemberg (for the period 1852–1893) and for Stuttgart school children (for the period 1912–1953). She found that both mortality and nutritional conditions related to trends and fluctuation in heights.

The present paper looks at the relationship of stature to infant mortality, breast feeding, and income. Much of the historical literature on breast feeding has focused on its beneficial effects on infant survival. (See, for example, Rollet and Vilquin, 1981; Reid, 2002.) A notable example is presented in the work of Robert Morse Woodbury (1926), who summarized the results of surveys done by the Children's Bureau in eight cities of the United States during the period 1911–1915. Table 2 presents some of those results. They indicate that income had the expected inverse relation to infant mortality and that groups with a higher prevalence of breast feeding had lower than expected infant mortality, given the level of income. For example, Polish and Portuguese immigrant women had about the same percent of husbands with low income, but the more extensive breast feeding among Polish women resulted in a lower infant mortality rate. The same comparison can be made between Jewish, German, and French-Canadian immigrant women. Kintner (1987) found that breast feeding was strongly negatively associated with infant mortality in Germany around 1910, using the same type of data presented in this paper. Even controlling for other factors (marital fertility, percent rural, percent Roman Catholic, medical doctors per 10,000 population, population density, percent births illegitimate, and the presence of infant welfare centers), breast feeding remained statistically significant, but it was less important than other factors because it largely affected only water-borne diseases of infancy.³

Since the mediating influence of the effects of breast feeding itself on later life outcomes would be infant and early childhood health and nutrition, most attention has been paid to those types of variables (e.g., Haines, Craig, and Weiss, 2003; Lee, 2003). The German data do afford a glimpse of the issue, although at an aggregated level.

³The standardized regression coefficients for marital fertility (Ig), percent Catholic, percent rural, medical doctors per capita, and percent illegitimate were all large than that for breast feeding. Breast feeding also had a non-linear relationship to infant mortality across geographic units. (Kintner, 1987, Table 3.)

THE STATURE OF GERMAN MILITARY PERSONNEL IN 1906

Map 1 through Map 4 afford a visual look at the patterns of infant mortality, breast feeding, and adult stature in Germany in the late 19th and early 20th centuries. Map 1 portrays the infant mortality rate (IMR or infant deaths per 1,000 live births) in 1878/1882, showing that the areas of highest infant mortality were in southern Bavaria, the Kingdom of Saxony, the east-Elbian provinces of Prussia, and in and around Berlin (Brandenburg). The lowest levels of infant mortality were found in the northwestern areas of the German Empire. Map 2 presents the same data for 1908/1912. Although the average infant mortality rate in Germany had declined from 225 in 1878/82 to 170 in 1908/12 (or about 25 percent), the pattern remained roughly the same. The zero-order correlation between the infant mortality rates across regions between the two periods is about 0.78. It is important to note that regional differences persisted.

Map 3 presents Evert's (1908) data on the heights of enlisted men, non-commissioned officers, and one year volunteers on December 1, 1906.⁴ There it appears that the shortest soldiers came from the south and southeastern parts of Germany: southern Bavaria, the Kingdom of Saxony, and Silesia (in east-Elbian Prussia). The tallest soldiers originated in the northern parts of Germany, especially from the northeast. This suggests that Map 3 is a rough mirror-image of Map 1 and Map 2. These are the areas of birth of the soldiers. These also correlate well with region of residence. In the *Berufszählung* of 1907, for example, only 8.7 percent of the German population was living outside their region of origin (Hoffmann, 1965, p. 180). By this time, 50 percent of all able-bodied German males who reached the age of 20 were conscripted into the military, mostly the army and largely the infantry. The term of service was two years (with an additional five years in the reserves). The total sample size of Evert's data was 621,210, which was about the size of the active serving German army (not including reserve units).⁵ It would have included longer serving regulars and non-commissioned officers. Although no age data are given, it is clear that most of these military men were at or close to their final adult heights. The average height of these soldiers was 167.8 cm, relatively short by modern standards and shorter than, for example, native white American soldiers in the Union Army during the Civil War (173.2 cm) (Haines and Steckel, 2000, Table 1).

Finally, Map 4 gives the areal distribution of the percent of German infants ever breast fed, roughly for the period 1903 to 1910. This time period was chosen because the data were most complete in geographic coverage. Also, the prevalence of breast feeding, rather than the mean duration of breast feeding was used because again the data were most complete (Kintner, 1985; Knodel and van de Walle, 1967). In any event, the percent of infants ever breast fed was strongly positively correlated with the average duration of breast feeding for all infants and those ever breast fed (Kintner, 1985, Table 3). It is important to note that there appears to have been persistence over time in these regional patterns of breast feeding. According to Kintner (1985, pp. 167–168), the practice of never breast feeding had been a long-standing tradition in central Europe (including southern Germany and adjacent Switzerland) dating back as early as the 15th century. Infants were often fed a meal pap (of cooked flour, milk, and water), oat or bran groats, zwieback soup, milk with zwieback and sugar, potato pap and paps made from a variety of other substances, bouillon, and even chicory coffee. While there is some evidence of variation over time in the percent of infants ever breast fed in Berlin between 1885 and 1910, with the percent ever breast fed falling from 78.5 percent in 1885 to 62.1 percent in 1905 and rising again to 70.1 percent in 1910, the large differences across regions did persist across the

⁴The data in Evert (1908) are not given consistently in the geographic detail by *Regierungsbezirk*. The *Regierungsbezirk* values were assigned for the provinces or *Laender* in which they resided.

⁵Evert (1908, p. 154) gives the number of unlisted men, non-commissioned officers, and one year volunteers in the army as 590,735 as of December 1, 1906. The comparable figure for the navy was 34,126.

late 19th and early 20th centuries. This is also important, since the breast feeding data for the period 1903/10 are used here to proxy infant feeding practices in the 1880s.

Comparing Map 1 through Map 4, it is apparent that where infant mortality was higher, soldiers tended to be shorter. Further, where breast feeding was less extensive, infant mortality tended to be higher and soldiers shorter. The mechanism would involve the fact that infants who are breast fed are less likely to suffer from bouts of disease, particularly gastrointestinal infections, and are also likely to be better nourished. This would lead to taller terminal heights. In order to examine the relationship more systematically, the data by geographic subunits were analyzed. Table 3 gives the results for the contemporaneous relationships while Table 4 relates the infant mortality rate in 1885 to heights in 1906 and breast feeding practices in the period 1903/10.

The contemporaneous analysis in Table 3 and the analysis linking 1885 with 1903/10 in Table 4 are quite similar, which is encouraging. Notably, breast feeding is a significant predictor of the infant mortality rate in both models, although the effects are stronger in the 1885/1910 model than in the 1910 model alone. A 10 percent increase in breast feeding would have resulted in a 5 percent decrease in the infant mortality rate in 1885, controlling for other factors.⁶ The same elasticities for 1910 would be 3 percent controlling for other factors and 6 percent not controlling for other factors. For the analysis of the effect on heights (the lower panels of Table 3 and Table 4), the effect of breast feeding diminishes in magnitude and is statistically insignificant when controlling for other factors, but is statistically significant when only region is controlled. The elasticities are also quite small. It is perhaps more illuminating to consider the coefficients themselves. Thus a German soldier or sailor born in the early to mid 1880s would have been about 1.4 centimeters taller in 1906 had he come from an area with 100 percent breast feeding rather than an area with no breast feeding. Moreover, an average soldier or sailor from the most favored region (Region 4, the North-Northwest Region) with about 82% or infants ever breast fed, would have been almost 2.2 centimeters taller than an average soldier coming from the least favored region (Region 7, the South Region) with about 63% of infants ever breast fed. Thus breast feeding, mediating through infant health and net nutrition, proxied by the infant mortality rate, did have a significant and important effect on this aspect of later life outcomes, namely final adult stature.

Among other interesting results is the fact that income per capita seemed to have little effect on the infant mortality rate (and hence on stature), whereas the level of urbanization, crowding (persons per dwelling), and the extent of in-migration had statistically significant negative effects on infant mortality. This is consistent with the view that, around the turn of the century, environmental factors were more important than individual level effects (see Voegele, 1997). The inclusion of marital fertility (Ig) obviously creates problems of endogeneity, but it has such an important impact that exclusion of this variable was deemed problematic. (A Hausman test clearly indicated endogeneity in those specifications with Ig on the right hand side.)

CONCLUSIONS

This paper has shown a statistical relationship across counties (Regierungsbezirke or the equivalent) in Imperial Germany such that significant variations in the heights of soldiers and sailors in the German military in 1906 were inversely correlated with infant mortality rates both around 1910 and around 1885, roughly twenty years prior to the information on military stature. The variations in the infant mortality rates were also inversely related to infant feeding practices, namely the prevalence of breast feeding in these regions (that is, the percent of infants ever breast fed). It is conjectured that a greater prevalence of breast feeding led to better infant

⁶The elasticity would have been 8 percent not controlling for other factors.

and early child hood health (as proxied by a lower infant mortality rate) and that this had an impact on at least one later life outcome, namely final adult stature. While individual-level longitudinal data would clearly be superior for this analysis, the evidence here is suggestive and is certainly consistent with the notion that breast feeding is not only healthy, but can lead to better biological outcomes later in life.

APPENDIX A

A NOTE ON THE CREATION OF REGIONAL INCOME ESTIMATES FOR GERMANY

The database used by this paper contains estimates of income per capital for the Regierungsbezirke of German. The methodology is based on the work of Thomas Orsagh (1968). He used the occupational distributions from the occupational censuses (Berufszählungen) of 1882, 1895, 1907, and 1925 to estimate a statistical relationship between known estimates of income in provinces in 1913 and 1926 (Germany, 1932) and the occupational structure of the provinces. In particular, he estimated the regression: (Income in 1913 = B(0) + B(1) Primary Sector Share in 1907 + B(2) Secondary Sector Share in 1907 + B(3) Tertiary Sector share in 1907), where the primary sector is agriculture, forestry and fisheries; the secondary sector is manufacturing; and the tertiary sector is services, following the basic categorization of Colin Clark (1940). The sectoral shares were the shares not within the geographic areas but shares in the total national income of Germany. The coefficients b(1), B(2), and B(3) were then applied to the sectoral shares of the regions in all of Germany for 1895 and 1882. In the present case, his relationship was re-estimated and the coefficients were applied to Regierungsbezirke shares in 1882, 1895, and 1907, rather than to the larger provincial units. The results were divided by population estimates at each date to get per capita incomes and then normalized so that the total for all of Germany was equal to the estimated net national product per capita calculated from Walther G. Hoffmann's compendium of German historical statistics (Hoffman, 1965, Table 248).

BIBLIOGRAPHY

- Barker, DJP. Fetal and Infant Origins of Adult Disease. London, England: British Medical Journal Publishing Group; 1992.
- Barker, DJP. Mothers, Babies, and Disease in Later Life. London, England: British Medical Journal Publishing Group; 1994.
- Clark, C. The Conditions of Economic Progress. London, England: Macmillan & Co. Ltd.; 1940.
- Craig, LA.; Weiss, T. Nutritional status and agricultural surpluses in the antebellum United States. In: Komlos, J.; Baten, J., editors. The Biological Standard of Living in Comparative Perspective. Stuttgart: Franz Steiner Verlag; 1998. p. 190-207.
- Evert, G. Zeitschrift des Koeniglich Preussischen Statisticshen Landesamts. Ergaenungsheft XXVII. Berlin: Verlag des Koeniglichen Statistischen Landesamts; 1908. Die Herkunft der deutschen Unteroffiziere und Soldaten am 1. Dezember 1906.
- Fogel, RW. Nutrition and the decline in mortality since 1700: Some preliminary findings. In: Engerman, SL.; Gallman, RE., editors. Long-Term Factors in American Economic Growth. Chicago: University of Chicago Press; 1986. p. 439-555.
- Fogel RW. New sources and new techniques for the study of secular trends in nutritional status, health, mortality, and the process of aging. Hist. Methods 1993;26:5-43.
- Germany. Statistisches Reichsamt. Einzelschriften zur Statistik des Deutschen Reichs. Nr. 24. Berlin: Verlag von Reimar Hobbing; 1932. Das deutsche Volkseinkommen vor und nach dem Krieg.
- Haines, MR. Health, height, nutrition, and mortality: Evidence on the 'Antebellum Puzzle' from Union Army recruits for New York State and the United States. In: Komlos, J.; Baten, J., editors. The

- Biological Standard of Living in Comparative Perspective. Stuttgart: Franz Steiner Verlag; 1998. p. 155-180.
- Haines MR, Craig LA, Weiss T. The short and the dead: Nutrition, mortality, and the 'Antebellum Puzzle' in the United States. *J. Econ. Hist* 2003;63:385-416.
- Haines MR, Kintner HJ. The mortality transition in Germany, 1860-1935. *Hist. Methods* 2000;33:83-104.
- Haines MR, Steckel RW. Childhood Mortality & Nutritional Status as Indicators of Standard of Living: Evidence from World War I recruits in the United States. *Jahrbuch fuer Wirtschaftsgeschichte* 2000;2000/1:43-59.
- Hoffmann, WG. *Jahrhunderts*. Berlin: Springer-Verlag; 1965. Das Wachstum der deutschen Wirtschaft seit der Mitte de 19.
- Kintner HJ. Trends and regional differences in breastfeeding in Germany from 1871 to 1937. *J. Family Hist* 1985;10:163-182.
- Kintner HJ. The impact of breastfeeding on regional differences in infant mortality in Germany, 1910. *European J. Population* 1987;3:1-29.
- Knodel, J. *The Decline of Fertility in Germany, 1871-1939*. Princeton, NJ: Princeton University Press; 1974.
- Knodel J. Breastfeeding and population growth: assessing the demographic impact of changing infant feeding practices in the Third World. *Science* 1977;198:1111-1115. [PubMed: 929189]
- Knodel J, van de Walle E. Breast Feeding, fertility, and infant mortality: An analysis of some early German data. *Population Studies* 1967;21:109-131.
- Komlos, J., editor. *Stature, Living Standards, and Economic Development: Essays in Anthropometric History*. Chicago: University of Chicago Press; 1994.
- Komlos, J. *The Biological Standard of Living in Europe and America, 1700-1900*. Eng.: Variorum, Aldershot; 1995a.
- Komlos, J., editor. *The Biological Standard of Living on Three Continents: Further Explorations in Anthropometric History*. Boulder, CO: Westview Press; 1995b.
- Komlos, J.; Baten, J., editors. *The Biological Standard of Living in Comparative Perspective*. Stuttgart: Franz Steiner Verlag; 1998.
- Lee, C. Prior Exposure to Disease and Later Health and Mortality: Evidence from Civil War Medical Records. In: Costa, DL., editor. *Health and Labor Force Participation over the Life Cycle: Evidence from the Past*. Chicago: University of Chicago Press; 2003. p. 51-87.
- Martorell, R. Child Growth retardation: A discussion of its causes and its relationship to health. In: Blaxter, K.; Waterlow, JC., editors. *Nutritional Adaptation in Man*. London and Paris: John Libby; 1985. p. 13-29.
- Martorell, R.; Habicht, JP. Growth in early childhood in developing countries. In: Faulkner, F.; Tanner, JM., editors. *Human Growth: A Comprehensive Treatise*. Vol. Vol. 3. NY: Plenum Press; 1986. p. 241-262.
- Menken J, Kuhn R. Demographic effects of breastfeeding: Fertility, mortality, and population growth. *Food and Nutrition Bulletin* 1996;17:349-363.
- Mitchell, BR. Vol. 4th ed.. New York: Stockton Press; 1998. *International Historical Statistics: Europe, 1750-1993*.
- Orsagh T. The probable geographical distribution of German income, 1882-1963. *Zeitschrift fuer die gesamte Staatswissenschaft* 1968;124:280-311.
- Reid A. Infant feeding and post-neonatal mortality in Derbyshire, England, in the Early twentieth century. *Population Studies* 2002;56:151-166. [PubMed: 12206165]
- Rollet, C.; Vilquin, E. *Infant Feeding, Fosterage, and Infant Mortality in France at the End of the 19th Century*. Vol. Editions de l'I.N.E.D.. Paris: 1981.
- Steckel RH. Height and per capita income. *Hist. Methods* 1983;16:1-7. [PubMed: 11614599]
- Steckel RH. A peculiar population: The nutrition, health, and mortality of American slaves from childhood to maturity. *J. Econ. Hist* 1986;46:721-741. [PubMed: 11617309]
- Steckel RH. Stature and the standard of living. *J. Econ. Literature* 1995;33:1903-1940.

- Steckel, RH.; Floud, R., editors. Health and Welfare during Industrialization. Chicago: University of Chicago Press; 1997.
- Tanner, JM. A History of the Study of Human Growth. New York: Cambridge University Press; 1981.
- Twarog, S. Heights and living standards in Germany, 1850–1939: The case of Wuerttemberg. In: Steckel, RH.; Floud, R., editors. Health and Welfare during Industrialization. Chicago: University of Chicago Press; 1997. p. 285-330.
- Voegele, J. Urbanization, infant mortality and public health in Imperial Germany. In: Corsini, CA.; Viazzo, PP., editors. The Decline of Infant and Child Mortality: The European Experience, 1750–1990. The Hague: Martinus Nijhoff; 1997. p. 109-127.
- Wolpin, KI. Determinants and consequences of the mortality and health of infants and children. In: Rosenzweig, MR.; Stark, O., editors. Handbook of Population and Family Economics. Amsterdam: Elsevier Science Publishers; 1997. p. 483-557.
- Woodbury, RM. Infant Mortality and its Causes. Baltimore, MD: The Williams and Wilkins Company; 1926.

Map 1.
Infant Mortality Rate, Germany, 1880

Map 2.
Infant Mortality Rate, Germany, 1910

Map 3.
Heights of Military Recruits, Germany, 1906

Map 4.
Percent Infants Ever Breast Fed, Germany 1910

Table 1

Variable Definitions. Regierungsbezirk of Germany, 1885, 1906, 1910.

Variable Name	Definition
imr	Infant mortality rate (infant deaths per 1,000 live births) (1883/87 for the 1885 database and 1908/12 for the 1910 database)
income	Estimated income per capita (1882 for the 1885 database and 1907 for the 1910 database)
urban	Population in urban places of 20,000 population and over (1885 and 1910 censuses)
fertility	Coale's Index of Legitimate Fertility (lg) (based on legitimate births average for 1883/87 for the 1885 database and 1908/12 for the 1910 database and married women by age from the censuses of 1885 and 1910)
dwelling	Persons per occupied dwelling (1885 and 1910 censuses)
cath	Proportion of the population Roman Catholic (1885 and 1910 censuses)
doctors	Medical doctors per 10,000 population (1887 for the 1885 database and 1909 for the 1910 database)
migration	Rate of net migration since the previous census, estimated by the residual method (migration = (Population at census 2) – (Population at census 1) + Births – Deaths)
breastfed	Percentage of infants ever breast fed (approximately 1903–1910) (Kintner, 1985; Knodel and van de Walle, 1967; and unpublished data)
height	Heights (cm) of soldiers currently serving in the German military (enlisted men and non-commissioned officers), December 1, 1906 (Evert, 1908)

Table 2

Infant Mortality, Eight American Cities, 1911–1915. (a)

INFANT MORTALITY RATES BY INCOME OF FATHER & PER CAPITA FATHER'S INCOME						
FATHER'S INCOME	IMR	RATIO	FATHER'S INCOME PER CAPITA	IMR	RATIO	
< \$450	166.9	151.7	< \$50	215.9		196.3
\$450–\$550	125.6	114.2	\$50–\$100	141.8		128.9
\$550–\$650	116.6	106.0	\$100–\$200	123.2		112.0
\$650–\$850	107.5	97.7	\$200–\$400	96.1		87.4
\$850–\$1,050	82.8	75.3	\$400 & over	60.5		55.0
\$1,050–\$1,250	64.0	58.2	\$1,250 & over	59.5		53.7
\$1,250 & over	59.1	53.7	No earnings	210.9		191.7
No earnings	210.9	191.7	Not reported	139.7		127.0
TOTAL	110.0	100.0	TOTAL	110.7		100.0

INFANT MORTALITY RATES BY INCOME OF FATHER & NATIVITY OF MOTHER						
FATHER'S INCOME	TOTAL		NATIVE WHITE		FOREIGN-BORN WHITE	
	IMR	RATIO	IMR	RATIO	IMR	RATIO
< \$450	166.9	151.7	170.0	181.0	167.1	135.1
\$450–\$550	125.6	114.2	121.0	128.9	118.4	95.7
\$550–\$650	116.6	106.0	110.8	118.0	121.8	98.5
\$650–\$850	107.5	97.7	99.5	106.0	119.6	96.7
\$850–\$1,050	82.8	75.3	76.4	81.4	94.9	76.7
\$1,050–\$1,250	64.0	58.2	62.6	66.7	68.4	55.3
\$1,250 & over	59.1	53.7	57.6	61.3	60.0	48.5
No earnings	210.9	191.7	187.5	199.7	234.2	189.3
TOTAL	110.0	100.0	93.9	100.0	123.7	100.0

INFANT MORTALITY RELATED TO BREASTFEEDING & ETHNICITY

	% WITH		RATIO ACTUAL/EXPECTED DEATHS	
	% ARTIFL. FEEDING	INCOME <\$650	PARTLY BREASTFED	ENTIRELY ARTIFICIAL
ALL MOTHERS	24.9	42.4	129.5	400.8

INFANT MORTALITY RATES BY INCOME OF FATHER & PER CAPITA FATHER'S INCOME						
FATHER'S INCOME	IMR	RATIO	FATHER'S INCOME PER CAPITA	IMR	RATIO	
WHITE	25.2	39.6	108.3	139.2	410.5	
NATIVE	28.3	27.4	93.8	170.7	534.5	
FOREIGN-BORN	21.2	55.3	127.0	125.1	327.4	
ITALIAN	13.1	70.5	103.8	85.9	219.0	
JEWISH	11.3	44.5	53.5	46.9	290.9	
FRENCH-CANADIAN	44.0	43.2	171.3	182.7	241.1	
GERMAN	21.5	41.2	103.1	125.0	564.5	
POLISH	11.1	78.3	157.2	159.8	487.8	
PORTUGUESE	31.9	78.5	200.3	237.6	429.4	
OTHER	23.2	45.0	129.6	102.3	325.4	
COLORED	19.7	81.9	154.4	82.2	315.8	
TYPES OF FEEDING BY COLOR AND ETHNICITY OF MOTHER						
	TOTAL MONTHS LIVED FROM BIRTH TO END OF 9th MONTH	% OF MOS. EXCLUSIVE BREASTFEED	% OF MOS. PARTLY BREASTFEED	% OF MOS. ARTIFICIALLY FED ^(b)		
ALL MOTHERS	192212.5	57.4	17.6	24.9		
WHITE	180397.5	57.6	17.1	25.2		
NATIVE	102285.5	56.2	15.4	28.3		
FOREIGN-BORN	78112.0	59.4	19.3	21.1		
ITALIAN	11943.0	68.6	18.3	13.1		
JEWISH	10688.0	61.5	27.1	11.3		
FRENCH-CANADIAN	8666.0	42.7	13.3	44.0		
GERMAN	6514.0	56.5	22.0	21.5		
POLISH	10391.5	65.9	22.7	11.1		
PORTUGUESE	5410.5	48.8	19.3	31.9		
OTHER	24471.0	60.3	16.5	23.2		
NOT GIVEN	18.0	27.8	33.3	38.9		

INFANT MORTALITY RATES BY INCOME OF FATHER & PER CAPITA FATHER'S INCOME					
FATHER'S INCOME	IMR	RATIO	FATHER'S INCOME PER CAPITA	IMR	RATIO
COLORED	11815.0	54.8	25.5	19.7	

(a) Cities were: Johnstown, PA; Manchester, NH; Saginaw, MI; Brockton, MA; New Bedford, MA; Waterbury, CT; Akron, OH; and Baltimore, MD. The study was based on samples totaling 22,967 livebirths and 2555 infant deaths.

(b) Number of months to the end of the ninth month.
SOURCE: Woodbury (1926).

Table 3

Relationship of Infant Mortality, Infant Feeding, and Adult Stature, Germany 1910. (Weighted Least Squares. Weights = Total Population, 1910)

Dependent Variable: Infant Mortality Rate, 1908/12									
		Correlations		Coeff.	Signi.	Coeff.	Signi.	Coeff.	Signi.
Independent Variables									
Constant				110.851	*	177.836	***	189.264	***
income		-0.292		-0.007	---	-0.012	---		
urban		-0.193		113.109	***	97.978	***		
fertility		0.196		220.677	***	171.812	**		
dwelling		-0.024		-1.591	***	-1.303	**		
cath		0.176		19.766	---	11.172	---		
doctors		-0.188		-2.835	---	-3.358	---		
migration		-0.255		-5.137	***	-4.130	**		
breastfed		-0.616				-0.620	***	-1.286	***
Regions:									
Region1		0.170		-11.167	---	1.482	---	-3.170	---
Region2		0.279		27.620	**	20.567	*	4.250	---
Region3		0.177		30.494	**	31.583	***	-6.208	---
Region4		-0.319		-30.918	**	-26.037	**	-56.515	***
Region5		-0.350		-48.383	***	-31.866	**	-46.578	***
Region6		-0.433		-48.042	***	-39.410	***	-80.001	***
Region7		0.287		NI		NI		NI	
N		60		60		60		60	
Adjusted		R-square		0.678		0.721		0.499	
F-ratio				10.55	***	11.91	***	10.78	***
Dependent Variable: Heights of Military Recruits, 1906									
		Correlations		Coeff.	Signi.	Coeff.	Signi.	Coeff.	Signi.
Independent Variables									
Constant				166.247	***	166.138	***	167.022	***
imr		-0.6259		0.000	---				
urban		0.2862		-1.251	**				
fertility		-0.0597							

Dependent Variable: Infant Mortality Rate, 1908/12						
	Correlations	Coeff.	Signi.	Coeff.	Signi.	Coeff.
dwelling	0.1135	0.019	---			
cath	-0.1903	-1.174	***			
doctors	0.1042	0.143	*			
migration	0.2407	0.037	---			
breastfed	0.4718	0.007	---	0.015	***	
Regions:						
Region1	0.1324	0.194	---	0.065	---	0.376
Region2	-0.3456	0.128	---	0.599	***	0.604
Region3	0.1177	-0.593	**	-0.224	---	0.059
Region4	0.1001	1.514	***	1.849	***	2.147
Region5	0.3823	1.526	***	1.146	***	1.566
Region6	0.1424	0.197	---	0.520	---	0.876
Region7	-0.4393	NI				NI
N	60	60		60		60
Adjusted	R-square	0.733		0.676		0.629
F-ratio		13.44	***	18.59	***	17.69

Source: See text.

*** = significant at least at a 1% level

** = significant at least at a 5% level

* = significant at least at a 10% level

--- = not significant at least at a 10% level

NI = not included

Table 4

Relationship of Infant Mortality, Infant Feeding, and Adult Stature, Germany 1885. (Weighted Least Squares. Weights = Total Population, 1885)

Dependent Variable: Infant Mortality Rate, 1883/87		Correlations	Coeff.	Signi.	Coeff.	Signi.	Coeff.	Signi.
Independent Variables								
Constant			17.077	---	213.792	**	271.107	***
income	0.125		-0.010	---	-0.006	---		
urban	0.121		-3.754	***	43.659	---		
fertility	0.071		380.636	**	222.212	**		
dwelling	0.183		-2.641	---	-1.381	---		
cath	0.143		2.995	---	-3.054	---		
doctors	0.090		3.757	---	-0.079	---		
migration	0.253		5.911	***	3.287	**		
breastfed	-0.768				-1.458	***	-2.452	***
Regions:								
Region1	-0.044		-33.476	---	-10.526	---	-49.046	**
Region2	0.230		38.661	*	5.588	---	-12.984	---
Region3	0.197		-0.549	**	15.189	---	-14.802	---
Region4	-0.337		-70.976	---	-59.567	***	-105.059	***
Region5	-0.394		-147.291	**	-89.980	***	-96.441	***
Region6	-0.299		-64.488	***	-48.672	***	-107.760	***
Region7	0.405		NI		NI			
N	54		54		54		54	
Adjusted	R-square		0.736		0.825		0.461	
F-ratio			12.36	***	18.82	***	8.57	***
Dependent Variable: Heights of Military Recruits, 1906		Correlations	Coeff.	Signi.	Coeff.	Signi.	Coeff.	Signi.
Independent Variables								
Constant			166.877	***	166.158	***	167.018	***
imr	-0.676		-0.001	---				
urban	0.212		0.366	---				
fertility	-0.064							

Dependent Variable: Infant Mortality Rate, 1883/87		Correlations		Coeff.	Signi.	Coeff.	Signi.	Coeff.	Signi.
perdwell	0.104	0.034	*						
cath	-0.223	-1.018	***						
doctors	0.199	0.205	**						
migration	0.030	-0.665	***						
breastfed	0.461	-0.004	---			0.014	***		
Regions:									
Region1	0.179	0.378	---			0.157	---	0.470	*
Region2	-0.346	-0.274	---			0.575	**	0.571	**
Region3	0.126	-0.403	**			-0.206	---	0.082	---
Region4	0.135	1.459	***			1.854	***	2.159	***
Region5	0.339	1.836	***			1.147	***	1.549	***
Region6	0.160	0.252	---			0.528	---	0.880	***
Region7	-0.415	NI				NI			
N	54	54				54		54	
Adjusted	R-square	0.784				0.640		0.590	
F-ratio		15.79	***			15.47	***	14.67	***

Source: See text.

*** = significant at least at a 1% level

** = significant at least at a 5% level

* = significant at least at a 10% level

--- = not significant at least at a 10% level

NI = not included