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Schooling and the Decline of Infant Mortality in Europe

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Jonas Ljungberg

A Scientific Revolution that Made Life Longer.

Schooling and the Decline of Infant Mortality in Europe

Abstract

This paper addresses the decline in infant mortality that occurred with a remarkable synchronization across Europe around the turn of the century 1900. It is the argument of this paper that this development is not just, as in the conventional view, the side effect of economic growth but could be derived through a cumulative chain of events, starting with the discovery of the germ theory. Mokyr has argued, that notwithstanding the ubiquitous impact of the germ theory in several fields, its first big effect, as a decline in mortality, came through changed behaviour in the household. What makes this plausible is that the turn-down occurred at the about the same time irrespective of the wide variations in levels of infant mortality, and irrespective of levels of aggregate income and economic growth. Growth was certainly crucial for sustaining the decline in mortality but the synchronized change of the trend draws attention to a shift in behaviour. A critical question for this argument is if the germ theory and its implications were so quickly and widely diffused. Schooling was an instrument for this diffusion and could be so since there existed an international movement around *school hygiene* which made the impact of the germ theory more pervasive than if it had only influenced via the curriculum. This hypothesis is supported by a cross-country model which singles out the enrolment in primary schools as an explanatory factor for the decline in infant mortality 1890-1910, and the more so when female enrolment is considered.

Key words: infant mortality, longevity, germ theory, school hygiene, schooling

JEL classification: I00, N33, O33

I. Introduction

The neolithic revolution and the industrial revolution are commonly considered as the two big discontinuities in human history. Certainly these both were important steps in the improvement of productivity which has been fundamental for subsequent developments. However, one can argue that there is yet another big discontinuity which has had an even more path breaking impact on human wellbeing but which is often overlooked or much confused. The discontinuity is manifest in the remarkable increase of longevity which began in Europe in the late nineteenth century. Until 1870, no European country had a life expectancy at birth over 50. The norm was rather below 40. Among the large countries only the English could expect to live beyond 40, whereas the French average hovered around 35, the German slightly above that but Italians born in 1870 could not even expect to attain their 30th birthday. On the eve of the First World War things had changed. The West European norm was around 50. Italians had added 20 years to their lives, as had the Dutch who were approaching a life expectancy of 60. At this level were already the Scandinavian countries, or at least the females of that northern region. Since 1914 progress, in this respect, has been continuous both over time and space and extended longevity in advanced countries as well as in countries at a much lower level of income. It is the argument of this paper that this development is not just, as in the conventional view, the side effect of economic growth but could be derived through a cumulative chain of events, starting with the discovery of the germ theory. This discovery caused innovation in technology, in particular with a bearing on the household, raised the general level of human capital and continued to generate scientific discoveries in biology and medicine. The big impact, as a decline in mortality, came first and primarily through changed behaviour in the household.

This argument has been persuasively elaborated by Joel Mokyr (2000; see also 1993 and, together with Stein, 1997). The decisive breakthrough of the germ theory is placed, by Mokyr (2000), in the larger context of “three major scientific revolutions.” The first is more like a process grown out of the Enlightenment than a particular breakthrough. It is a bit vaguely defined as the awareness of a connection between filth and disease which further gained ground with the “statistical movement” in the nineteenth century. Pasteur’s germ theory represents the second of these “scientific revolutions” and the third came with the new insights in nutritional science in the twentieth century. All three caused shifts in the production function of the household with great impact on living standards. Without denying the cumulative character of this history and the role of path dependency in scientific discoveries, I will focus here on the impact of the germ theory as a particularly causal factor of the sudden leap in longevity. Mokyr has worked out the theory, based on the role of "useful knowledge" (Kuznets 1966: 86-7), within the historical context of the decline in mortality, particularly infant mortality, but no adequate test with empirical data has been provided. This is the task of the present paper. In order to carry out this task, it is motivated to discuss previous explanations of the decline in infant mortality as well as the role of infant mortality for the increase of life expectancy.

The next section of the paper pursues a critical discussion of the literature on the decline in infant mortality. Section three, titled "the impact of Pasteur" provides some evidence for how broadly the germ theory gained influence in the elementary school system. Section four assesses the role of infant, and other age specific, mortality for the increase in longevity in some European countries. Section five takes a look at the difference in levels of infant mortality across Europe, before in section six, a comparative analysis of the decline in European infant mortality 1890-1914 is carried out. A Barro-type cross-country regression is singling out enrolment in primary education as the important determinant. It is argued that this supports the idea that the germ theory, popularized and embodied in new generations of human capital, was a causal factor for the turn down of the infant mortality rate. Section seven concludes and extends the discussion to limitations for our understanding of the mortality decline posed by methodological and ideological hang-ups.

II. Explanations of the decline in infant mortality

It is an undisputed fact that over large parts of Europe infant mortality suddenly began to decline from high levels in the late nineteenth century or around 1900 (Corsini and Viazzo 1997: xiii; Livi Bacci 2001: 149). The decline continued through the twentieth century, from levels between 100 and 300 per 1000 live births to less than a tenth of those horrifying figures, but it is striking how concerted the initial turn down appears (Leonard and Ljungberg 2010). At first sight, this might look like a result of the spread of industrialisation with economic growth and modernity. This was also very much the essence of the explanation of the mortality decline suggested by McKeown (1976) which, more precisely, ascribed the major cause to improved nutritional standards. However, the criticism against McKeown was devastating, for focussing too much on the British case, for passing over age-specific differences and infectious diseases, and for using a Sherlock Holmes methodology of sorting arguments by exclusion (Szreter 1988; Woods et al. 1988, 1989). While Szreter (1988, 1991) emphasised the public health actions, which were very much related to the above mentioned “statistical movement” or, with an up—dated terminology, the construction of social databases, the subsequent discussion has drawn attention to the diversity of mortality patterns. Much inspiration was fetched from the Princeton Project on fertility (Coale and Watkins 1986) despite that its painstaking collection of detailed data from more than 500 districts covering large parts of Europe gave a very inconclusive result. Or, more specifically, the expected sequence of a fertility decline following on a mortality decline was not supported and it was found that diversity dominated.[1]

Similarly to the study of European fertility decline, the search for explanations of the decline in infant mortality has been directed towards the diversity of factors in different historical contexts. Indeed, much light has been shed on the history of mortality decline in various countries, as in the volumes by Schofield et al (1991), Corsini and Viazzo (1993, 1997), Bideau et al. (1997), and also by comparative work such as Vögele (1998). Thus, factors such as social class, illegitimacy, urban-rural location, housing, female occupation, water and sewerage systems as well as other public health measures, all play a role but not along a consistent pattern. For Britain, Bell and Millward (1998, 2001) have drawn attention to, besides the municipal investments in sanitary systems, the role of the health status of the mothers. Also the general level of knowledge has been accounted for and Schofield and Reher (1991: 16-17) conclude:

> “Education and culture may not have been the only elements in the mortality transition, but their importance was far from negligible. One of the major conclusions which can be derived from reading the papers included in this volume is that there was no simple or unilateral road to low mortality, but rather a combination of many different elements ranging from improved nutrition to improved education.”

A response in research has been to dig even deeper for micro or individual-level data although it seems as if diminishing returns have set in, at least as regards the crucial question about the causal factors. Reid (2002), for example, uses micro data for early-twentieth century Derbyshire and advanced techniques, yet has to admit that her results were not unexpected and “have already been demonstrated in a variety of different settings.” Gregory (2008)

[1] Woods al (1988: 122) characterize the summing up by van de Walle (1986) as ”a cry of despair.”

interestingly maps the British mortality decline 1851-1911 with GIS, yet, the conclusion is well caught by the title, “different places, different stories.”

However, no-one can deny that several factors, in the general environment as well as in the household, have interacted in the decline of mortality. It is also probably true that without economic growth there had been no sustained decline, over the twentieth century, in mortality. Yet, the crucial question is whether there was any particular factor that was driving in the simultaneous beginning of the decline of European infant mortality around the turn of the century 1900. Pasteur and the germ theory have actually been much discussed but mostly about its revolutionizing impact on medical science and technology (e g Biraben 1991). Even if this curative impact began already in the nineteenth century, it is agreed that the measurable influence on mortality, from improved medical care, came first several decades into the twentieth century. Still, Morel (1991), also in the volume edited by Schofield et al., emphasises the improvement in parental care as a result of the new knowledge:

> “However, medical progress on its own was not sufficient, changes in attitude and behaviour were also needed. Those who cared for young children had to be convinced of the need for these new medicalized practices. In France, the government attempted to popularize the new rules of hygiene, particularly in those groups of the population in which infant mortality was highest, the new proletariat in the towns, where families often lived in conditions of squalor and promiscuity. A number of different methods were used in an attempt to reach these groups: child-care was taught in domestic-science lessons to girls in primary schools…A League against Infant Mortality was founded in 1902 and published leaflets and articles in the popular press in which advice was given for the prevention and cure of children’s illnesses.” (Morel 1991: 212)

As can be seen from those lines, the model developed by Mokyr has precedents and there are others, most notable is the work by Preston and Haines (1991). Its bottom line was neatly summarized in a lecture by Preston a few years later:

> “So if it wasn’t Big Medicine and it wasn’t diet, what was it? I’ll briefly summarize a book and several articles that I’ve written on this subject with several collaborators … These focus on the first half of the century, when the gains in life expectancy were fastest. I believe that the essential element in the gains was an enormous scientific breakthrough— the germ theory of disease. This theory was empirically validated in the 1880s and was beginning to displace the misguided miasma theories by the turn of the century. While the new theory led to few practical drugs, it led

> to an entirely new approach to preventative medicine, practiced both by departments of public health and by individuals.” (Preston 1996)

In this lecture, as well as in the referred works, is however the interpretation that the first significant Pasteur impact on mortality in the United States can be observed in the 1920s. Basically, the argument is that families of professionals, like physicians and teachers, had only marginally lower child mortality (five first years) than the average family in 1900, while in 1925 it was down to two thirds of the average. The background is said to be a delay in the acceptance of the germ theory by American medical doctors which supposedly was a constraint for the broader public diffusion. This argument is very much restated by Caldwell (1991) and similarly underpinned by anecdotal evidence of stubborn ignorance in the medical profession. Certainly such a resistance against the germ theory existed but that overall picture is very much in contrast to the conclusion by Mokyr which is built on a more comprehensive survey of contemporary media:

> “While the absorption of the full behavioral implications of germ theory took decades, what is surprising is how relatively quick and complete its triumph was by 1914, delivering sharp declines in infectious disease decades before the introduction of antibiotics.” (Mokyr 2000: 17)

How to resolve these discrepancies in interpretations? First, it should be noted that, notwithstanding the meticulous investigations of the US 1900 census data, the statistical analysis by Preston and Haines does not really match their interpretation. First, no account is taken of the time series behaviour of the infant or child mortality. Actually, it seems as if the American aggregate should have followed the European pattern of a turn-of-the-century decline. Unfortunately, we have no series on American infant mortality for the nineteenth century but from 1900 onwards the rate can be extracted from the lifetables provided by the Max Planck Institute for Demographic Research (www.lifetable.de). For the years 1900-1914, the US infant mortality closely concurred with the French, beginning with 162 and 160 per thousand live births, respectively, and reaching 107 and 111, for the US and France respectively (the French data from Mitchell 2003). Thus, a clear decline can be noticed in the American infant mortality at least from 1900, very similar to the European pattern. In 1925 the American infant mortality was down to 75, a cut by more than a half in the first quarter of the twentieth century, and more than families of professionals must have been affected. The other problem with the Preston and Haines data is that it is based on the census of 1900 which does not mean that the mortality pertain to this year but it is rather based on the number of children born by each woman, in case of child mortality back to 1886 (Preston and Haines 1991, p. 89). This explains the subtitle of the book, *Child Mortality in Late Nineteenth-Century America*, but in tables and text it is most frequently talk about “1900” which is a not unproblematic extrapolation. Anyway, for this early period one should not expect that any significant impact could be found from Pasteur’s germ theory and we are thus not helped for an explanation of the initial turn in the trend.

III. The impact of Pasteur

If we now turn to Europe, what is the evidence for a diffusion of the germ theory around the turn of the century 1900, sufficient to have an impact more or less across the continent? It is not enough to argue that the new ideas gained ground in France, as we saw above in the quote from Morel (1991). Mokyr and Stein (1997) argue that the new knowledge was taught in schools not only in France but also in England and that hygiene and health were part of the elementary curriculum well before 1890. In England in 1883 a grant was afforded to schoolgirls who attended lectures in housewifery, which was connected to the new view on hygiene and housekeeping, and the numbers taking these classes expanded rapidly (Bourke 1994: 183). In Sweden, cookery was introduced 1889, for girls in primary school in Stockholm, and spread over the country in the following years (Kommitterade 1914).

It would be a challenging task to investigate how well the new ideas permeated into curriculum and textbooks across different countries. However, besides being very laborious, it might not be the best indicator. Instead, one can study the guidelines for school boards and teachers’ seminars, in particular in the field of *school hygiene*. School hygiene had emerged as a discipline in Germany already in the eighteenth century with a treatise by Johann Peter Frank. In Sweden an early, if not the first textbook, was Goldkuhl (1883), largely building on German literature[2]. A part of this book, as also later contributions, contained of instructions for the school house, for example about light and ventilation. It is noteworthy that views in this book were reflecting more the idea of miasma than the germ theory and the instructions about toilets were treated in nine lines, emphasising that the privies of boys and girls should be placed on each side of the school yard. Nevertheless, a fourth of this book was devoted to contagious diseases even though no explicit mention was made of germs. In a curious mix of

[2] Acknowledgement is given to a broad list of foreign literature but the main source seems to have been A. Baginsky (1877), a textbook that came in a revised edition 1898. Even if this latter edition mentions germs, its structure is more reflecting the older tradition and despite its more than 700 pages no chapter or section is devoted to contagious diseases among school children.

old and new theory, soggy air was said to contain "living, infinitesimally small organisms, poisonous contagion matter which…generate diseases" (Goldkuhl 1883, p.6). A new textbook came in the mid-1890s (Almquist 1896). Here Pasteur and the germs are fully integrated. Sections about light and ventilation are, not without reason, retained but toilets and the quality of drinking water are treated in detail. Chapters on body care and contagious diseases are also put on the basis of the new science. The author was professor in hygiene at *Karolinska Institutet* and became a leading figure for the development of school hygiene in Sweden. A new, extended edition came in 1910. Another textbook appeared before the turn of the century (Wallis and Silvferskiöld 1899), an edited volume with more pages and also clearly based in the germ theory. The importance of these textbooks is that they reflect the awareness among school people and it is reasonable to infer that the new knowledge rather quickly gained a pervasive influence in the daily life of schools. In this way the impact was bigger than if the new ideas had only been part of the curriculum.

Hence, there is evidence for an early diffusion into elementary education of the germ theory, besides in France and England, also in Sweden. However, what about the rest of Europe? Twelve Europan states, including Turkey and Russia and four independent Italian states, were represented at the First International Sanitary Conference in 1851, in Paris. This, and a whole series of subsequent conferences were mainly engaged in the fight against cholera but successively broadened and in 1902 resulted in the *Office International d'Hygiene Publique*, with nine European and three other states as members (Minelli n.a.). Also in the field of school hygiene grew the international cooperation. In 1904, the first international conference on school hygiene was convened in Nürnberg, and three years later a second conference was held in London. That these were no suddenly upcoming or casual events is indicated by the immense number of delegates. The Nürnberg conference gathered 1,500 delegates from 19 European states and the USA, Chile, Cuba, and Japan. The London conference, which had king Edward as its patron, gathered 2,000 delegates (Törnell 1904; Stéenhoff 1907; Svanborg 1907). Probably the delegates on these conferences were fairly up to date already when they decided to go to the conference. Their number and the broad range of their origin indicate that modern ideas about preventive hygiene were widely diffused among school people in Europe at the turn of the century 1900. This is why one could expect that the extent of schooling in different countries should be related to the rate of decline in infant mortality.

IV. The role of infant mortality

It is often said that the decline of mortality in younger ages is most important for the rise in longevity. Yet, the proposition is more seldom substantiated and it is not invariably true. This can be seen from a comparison of the period 1890-1910 with the preceding twenty years, as shown in Table 1. From lifetables available for some European countries, it is estimated how many males should have survived until the age of 60, assuming the age-specific mortality of the given year should remain. It is clear from the table that in most countries the number of boys born who could expect to be alive at least until their 60th birthday increased significantly over the twenty years to about 1890. Over the next twenty-year period the increase was even higher and without exceptions among those countries from which data are available.

In lack of a standard for decomposition of longevity, I have further made the counterfactual assumption that mortality in certain ages has stayed constant since the previous benchmark year, and calculated how that would have affected the number of survivals. In this way the contribution to longevity from the decline of mortality in certain ages can be estimated. It is striking how little the decline of infant mortality contributed in the period 1870-1890, and even that the contribution was negative in England and Wales, and even more so in France. Only in Norway was there a significant contribution from decline in infant mortality, and together with early child mortality (second year of life) the contribution to the increase in longevity was 40 per cent. However, the increase of longevity in this period was modest in Norway where already in 1870 this was higher than what any of the other countries should achieve around 1890. In the following period longevity, as measured by the number of survivals to 60, increased more in all countries and a substantial part of the increase came from the decline of mortality during the first and second years of life. In France more than 60 per cent, in Austria 50 per cent, in the Netherlands and Germany well above 40 per cent of the increase in longevity came from the decline of mortality in this early age. Mortality in these two first years moved rather well together and increased their relative contribution to longevity when other age groups, including 2-5 years children, diminished theirs. If we switch to absolute numbers in different age groups, which could be derived from the table, mortality among 2-5 years old even worsened in the Netherlands, England and Wales, and Austria in the period 1890-1910.

For Russia the earliest lifetables pertain to 1896 and 1926, and these are included for a comparison. It is clear that Russia-Soviet lagged behind the other European countries, yet, the significant increase in longevity in the early twentieth century was very much dependent

Table 1. A measure of longevity and age specific contributions to its increase: European countries about 1870, 1890, and 1910

			Contribution to change since previous year in per cent from age group				
	Survival until 60 of 1,000 born	+	<1 year	1 year	2-5 year	6-9 year	10-59 year
Netherlands 1871	334	-	-	-	-	-	-
1891	443	109	9.9	9.7	22.0	8.0	50.2
1911	609	166	19.8	15.5	11.4	2.8	50.5
Germany 1871	311	-	-	-	-	-	-
1891	383	72	13.1	7.1	15.6	6.0	58.3
1911	477	94	32.5	9.6	12.2	3.2	42.5
England &Wales 1871	365	-	-	-	-	-	-
1891	410	45	-14.7	7.6	29.5	9.3	68.3
1911	521	111	27.3	8.6	8.0	1.0	55.1
France 1872	391	-	-	-	-	-	-
1892	396	5	-235	81.1	91.9	59.9	101.7
1912	476	80	50.3	10.6	13.6	3.6	21.9
Austria 1870	252	-	-	-	-	-	-
1889	327	75	5.4	5.0	24.3	8.1	57.2
1909	413	83	37.0	12.9	15.5	4.3	30.3
Norway 1871	460	-	-	-	-	-	-
1891	481	21	27.7	12.4	26.6	1.8	31.6
1911	577	96	23.0	9.1	15.2	6.1	46.6
Russia 1896	262	-	-	-	-	-	-
1926	379	117	42.0	10.9	20.5	5.7	20.8

Source: author’s calculations based on the Human Life-Table Databas (HLD) provided by the Max Planck Institute for Demographic Research (http://www.lifetable.de).

on the decline in infant mortality. A conclusion from this exploration of age specific mortality across a sample of European countries is that the turn of the trend of infant mortality indeed was important for the increase of longevity around the turn of the century 1900. Without this turn, the increase of longevity would have been more gradual and also left some countries much further behind. In the following only infant mortality, that is, the mortality during the first year of life, will be dealt with, because these are the only relevant data available as time series for a somewhat larger group of countries.

V. The difference in levels of infant mortality

It is a bit puzzling that the levels of infant mortality differed so much in the late nineteenth century. With the concerted decline around the turn of the century 1900, one might expect that this move began under similar conditions. This was however not the case. In some European countries, still in the early 1890s one in four, or even more, infants died before their first birthday. As seen in table 2, that applied to Russia, Austria, and Hungary. Germany as well as Romania were not much better. It is moreover striking that the infant mortality seems unrelated to the income level of the country. Germany and Austria belonged to the richer countries in Europe whereas Russia and Romania were amongst the most poor. The same lack of match between infant mortality and income level is highlighted by poor Serbia and rich Netherlands which in the early 1890s had roughly the same infant mortality rate. "Best in class" were Norway and Ireland, not very rich countries at that time, whereas richer countries both in the British Isles as well as on the continent wasted a far larger share of their breed. Even more puzzling becomes the pattern, or lack of pattern, if we consider the change up to the years before the First World War. Ireland did not improve much, yet, Norway and Sweden took a clear lead, and relatively speaking previously malperforming Netherlands and Switzerland improved the most. In order to find a pattern, one has to go beyond income levels and also social inequality, even if social conditions were significant for differences within countries as is extensively dealt with in the literature, and somewhat reviewed in Leonard and Ljungberg (2010).

A major determinant of the level of infant mortality was the feeding practices. In regions and countries where infants were mostly breast-fed, such as in Scandinavia and Ireland, the babies survived to a larger extent. The high mortality in southern Germany and parts of Eastern Europe, including Russia, was largely due to the practice only to breast-feed during a short period, or not at all. Not only was the nutritional content of the artificial food, typically based on bread, inferior but a low hygienic standard also made it highly contagious of digestive diseases (Leonard and Ljungberg 2010). [3] That a lower rate of deaths due to

[3] Kintner (1987), on the basis of regional data for Germany in 1910, by controlling for other factors such as illegitimacy, access to medical care, urbanization, Catholicism etc, qualifies the impact of breast-feeding on levels of IMR. However, one should notice that the variable for breast-feeding is "percentage ever breastfed" which drastically reduces the variance of this variable in comparison with a measure including duration of breast-feeding. This is also indicated by the significance of taking the

Table 2. Deaths during the first year of life per 1,000 born (IMR) and births per 1000 in the population (CFR) in Europe, 1890-1914

Country (in brackets limitation of data)	**IMR 1890/94**	**IMR 1910/14**	**IMR % change**	**CFR 1890/94**
Austria	248.8	187.8	-24.5	37.0
Belgium	162.8	136.4	-16.2	29.3
Bulgaria (1892-1910)	144.3	149.3	3.5	36.6
Denmark	138	98.2	-28.8	30.5
Finland	147.8	111.6	-24.5	32.0
France	169.6	118.8	-30.0	22.4
Germany	223.6	163.2	-27.0	36.2
Hungary (1891-1910)	255.3	197.4	-22.7	41.7
Ireland	99.8	91.8	-8.0	22.8
Italy	186.6	138.6	-25.7	33.0*
Netherl	166	103.6	-37.6	31.6*
Norway	98.2	66.2	-32.6	30.1
Romania (1892-94; 1912-14)	221.4	222	0.3	40.2
Russia (1892-1910)	277.6	254	-8.5	49.0
Serbia (1890-1910)	169.2	139	-17.8	42.5
Spain (1884-88; 1910-14)	187.2	151.2	-19.2	35.2
Sweden	104.4	72.2	-30.8	27.6
Switzerl	155	102.2	-34.1	27.5
Engl & W	148.8	108.6	-27.0	30.5
Scotland	125.8	109.2	-13.2	30.6
Unweighted average	171.5	136.1	-20.3	33.4

Source: Mitchell (2003). CFR for Italy and Netherlands is in 1900, not included in the average.

diarrhoea was an early factor in the decline of infant mortality (Vögele 1998) suggests indeed that better knowledge among mothers had a particular role.

However, a change from hand-feeding to breast-feeding cannot explain the decrease in infant mortality that occurred in the decades before 1914. For example, breast-feeding dominated already in Scandinavia where the drop was substantial. It can also be noted that no general increase of breastfeeding took place in Germany during this period and nevertheless infant mortality dropped. In the more advanced countries the Public Health movement

quadratic term of breast-feeding, which is done by the author, but it does not account for the duration effect. Moreover, the year of comparison is 1910 when the effect of the Pasteur revolution was already under way.

emerged in the nineteenth century, and it is often considered important for the rise in life expectancy. However, the geographical diffusion of the drop in infant mortality preceded the diffusion of the Public Health movement and improvements in sanitary infrastructure. Even in the country of its origin, Britain, it was probably of less importance as regards the infant mortality in this period (Bell and Millward 1998). A simple reason for that is that the awareness of the alarmingly high infant mortality was, from the perspective of a later time, not very alert. As long as the knowledge about preventive health care was very limited or faulty, a fatalistic view prevailed among parents. The mentality is aptly characterized in a work on parent-child relations during the long-nineteenth century: "The biblical saying 'the Lord gave and the Lord hath taken away,' was ingrained in people's minds, instilling faith in divine providence and placidity in the face of the vicissitudes of life" (Guttormsson 2002: 255).[4]

VI. The decline in infant mortality

One of the early, and maybe the most insightful, voices against infant mortality was George Newman, a British MOH (Medical Officer of Health) and medical doctor, who in 1906 published the book *Infant Mortality. A social Problem* (Newman 1906). This work is still unrivalled as regards the thorough discussion of the problem on the basis of data from a broad range of countries with particular emphasis, of course, on England and Wales (for a discussion of Newman, see Garret et al 2006). The major cause of the high infant mortality was, according to Newman, ignorance as to the necessities of child rearing, "chiefly, perhaps, in feeding, uncleanliness, and exposure" (Newman 1906: 221). Newman based his argument on experience and observations as a MOH but also on statistical evidence of a correlation between infant mortality and illiteracy. The infant mortality rate and the number of illiterate women per 1000 married are thus tabulated for 44 counties in a rising order which is broadly matching. A calculation of the correlation on Newman's data gives r=0.589 which is equal to a statistical significance below 2 per cent. Much research, not the least for England and Wales, has shown that infant mortality variated closely with social class and income but illiteracy has been ignored. One might suppose that the female illiteracy was correlated with

[4] However, Rollet (1997) argues that the fatalistic mentality began to change already in the 1860s but it seems that this was more a concern about the disastrous consequences of wet-nursing, in particular in France. Although single voices in the 1870s drew attention, in England, to the waste of infants this "fell largely on deaf ears and it would take a further twenty-five years before a concerted effort was made to reduce national IMRs." (Galley 2006: 25; see also Szreter 1988)

lower incomes and that the correlation primarily reflects social inequality. However, Newman discussed and rejected that explanation, emphasising that parental ignorance was crucial.

It is beyond the scope of this paper to try to settle that question for England and Wales, yet, would it be possible to map female illiteracy across Europe and maybe find a pattern that like hand-feeding shows a connection with a high infant mortality? Maybe or maybe not. But the point is that even with the best of knowledge in, say, the 1870s, infant mortality would have remained high.[5] Until germ theory was robustly shown and had won hegemony it was believed that disease spread through *miasma* as nasty odour. The germ theory generated knowledge about the causes of infectious diseases and about pre-emptive behaviour as regards personal hygiene and the handling of food. Thus the preventive impact of the germ theory had a broader and earlier effect than its curative impact, notwithstanding that sterile surgery and other applications of the germ theory spread in the two last decades of the nineteenth century. The impact of the new knowledge on human behaviour was immense, not the least in households, and this propelled much of the improvement in health.

Thus, as suggested elsewhere (Leonard and Ljungberg 2010) while the extent of breast-feeding accounts for much of the difference in levels of infant mortality across Europe, the diffusion of the new technology of the modern household accounts for much of its rapid decline around the turn of the century 1900. While Mokyr has shown with evidence from the popular press, magazines and books that the new technology had a breakthrough in the USA before 1914, its impact on infant mortality remains to be shown. In this context is the international unfolding of *school hygiene* and the enrolment in schooling of relevance. It is plausible to assume that school hygiene contained both consciousness of the germ theory and a tool for its further diffusion through the school system. Hence, enrolment in elementary schooling can be taken as an indicator of the diffusion of the new technology based on the germ theory.

A test on the hypothesis can be performed through a comparison of the decline in infant mortality and enrolment in primary schooling. A comprehensive set of decadal data on enrolment in primary schooling for the relevant period is provided by Lindert (2004). 1880 could be chosen since girls in school that year went through their childbearing about 1890-1910. However, this year had the germ theory not yet gained significant influence, as could be inferred from the review of the textbooks on school hygiene, and there are several gaps in the

[5] "It seems reasonable to maintain that general levels of knowledge prior to the discovery of bacteria would not have allowed – except in particular social and environmental situations – infant mortality to decline below about 150 per 1,000." (Livi Bacci 2001: 149)

data. 1890 has a better coverage in the enrolment data and even if the germ theory was still emerging in schools, this year can be representative for a part of the 1890s. Girls in school in the early 1890s were the young mothers a decade later and since infant mortality was generally higher in this group, these cohorts should be significant for the decline of infant mortality through the 1900s. Enrolment in 1890 varied widely in those European countries for which the comparison is pursued, from 99 per thousand in ages 5-14 in Russia to 832 in France (Lindert 2004). Unfortunately, the enrolment data are rather crude and do not reflect differences in the length of the school year. According to estimates for Sweden, enrolment in primary school between 1868 and 1910 increased only 16 per cent but the actual time children attended to school more than doubled (Ljungberg and Nilsson 2009). Such differences, as well as quality variations, are hidden in the available cross-country data and these can therefore only broadly reflect the variations in schooling.

Some control variables can be used even if data limitations exclude usual demographic and social variables. However, GDP per capita would reflect the general level of living standards, and its growth rate the tempo of modernisation. If McKeown is right these income variables would be important. The crude fertility rate is also available, at least from 1900, and both its level and change can be used as control variables. If the stage theory version of the demographic transition is right, these would be the important variables. Despite largely falsified by the Princeton Project (Coale and Watkins 1986; van de Walle 1986) the idea that there is a causal relation between the decline of infant mortality and the decline of fertility has got some revival (Reher 1999), and not the least in the so called unified growth theory (Galor 2005).

In the model enrolment in primary school is taken as an explanatory variable for the change in infant mortality over the period 1890-1910. Since infant mortality is decreasing the expected sign of enrolment is negative. The model also controls for GDP per capita in 1890 and the change in GDP per capita 1890-1910, also with expected negative signs. Besides, the level of infant mortality in 1890 also fertility in 1890 and the change in fertility 1890-1910 are controlled for. If there was a causal connection between fertility and the decline in infant mortality, in either direction, one could expect a positive correlation. With the level of infant mortality the reverse correlation might be expected, as shown in a regional analysis of the long-term infant mortality in Italy (del Panta 1997).

The model has the following form:

$$IMRCHANGE = \alpha - \beta1 * ENROL1890 - \beta2*GDPC1890 - \beta3 * GROWTH + \beta4*CFR1890 + \beta5 * CFRCHANGE - \beta6* IMR1890$$

where IMRCHANGE is the change in infant mortality, calculated as the trend over the period 1890-1910; ENROL1890 is enrolment in primary schooling in 1890; GDPC is the logged level of GDP per capita in 1890; GROWTH is its rate of change over the period 1890-1910; similarly with CFR1890 and CFRCHANGE as regards the crude fertility rate; finally IMR1890 is level of infant mortality in 1890. All variables except GDP per capita are in relative terms, and several with negative values, and not seen necessary to log.

In the full version (1) of the model no variable achieves statistical significance and the F-statistics also refutes the model. When two of the “worst” variables are avoided (2), F-statistics becomes acceptable despite only ENROL1890 is close to statistical significance with conventional standards. GDP per capita was retained in order to see if it at least should get the expected negative sign. It did not and this testifies what was said before, namely that the decline in infant mortality occurred independently of income levels. GROWTH could be connected with increasing earnings as well as infrastructural investments in urban areas and it

Table 3. OLS regression on infant mortality change among European countries 1890-1910

	(1)	(2)	(3)	(4)
Constant	0.0079 (0.909)	-0.0169 (0.749)	-0.0057 (0.457)	0.0006 (0.887)
ENROL1890	-0.0222 (0.142)	-0.0245 (0.052)	-0.0207 (0.014)	-0.0206 (0.013)
Ln(GDPC1890)	0.0007 (0.933)	0.0031 (0.666)		
GROWTH	-0.6962 (0.292)	-0.3008 (0.524)	-0.3546 (0.424)	
FER1890	0.0000 (0.919)			
FERCHANGE	0.0055 (0.153)	0.0057 (0.104)	0.0053 (0.104)	0.0044 (0.141)
IMR1890	0.0000 (0.913)			
Adjusted R2	0.283	0.336	0.372	0.385
F-stat prob.	0.170	0.043	0.018	0.008
Observations	16	19	19	19

Note: Sample of 16 countries are Austria, Belgium, Bulgaria, Denmark, Finland, France, Germany, Hungary, Ireland, Norway, Romania, Russia, Sweden, Switzerland, England & Wales, and Scotland; in sample of 19 Italy, the Netherlands, and Spain are added. Probability in parentheses. Enrolment data from Lindert (2004, p. 91 f) consider number of pupils in primary school as share per thousand in ages 5-14; IMR and fertility data from Mitchell (2003), for Italy and the Netherlands FERCHANGE is between 1900 and 1910; GDP per capita data from Maddison (2008), with series for Eastern Europe interpolated between benchmarks before estimating the trend 1890-1910.

has the expected sign but is far from statistical significance. The level of infant mortality in 1890 (IMR1890) had, as could be inferred already from an inspection of table 2, no influence on the decline at all. The regional convergence in infant mortality that has been noticed for some countries, often for an earlier period, had obviously other causes than the pan-European decline of the turn of the century. Similarly, the level of fertility (FER1890) had no importance for the decline. However, FERCHANGE was weakly related to the decline of infant mortality although it does not reach the conventional statistical significance. When left alone with ENROL1890 in (4) its probability is even reduced and although there were parallel developments, in infant mortality and fertility, here is no support for a close dependence. The only robust relation with the decline in infant mortality is demonstrated by ENROL1890, for which the values improves when the more spurious variables are dropped and in both (3) and (4) its statistical significance is close to the 1 per cent level.

Moreover, since it was obviously schooling for girls that had an impact on the later decline in infant mortality, it would be desirable to have female instead of general enrolment in schools. Lindert (2004) also provides figures for the female shares of primary school

Table 4. OLS regression, adjusted for female enrolment, on infant mortality change among European countries 1890-1910

	(1')	(3')	(4')
Constant	-0.0051 (0.936)	0.0047 (0.509)	0.0000 (0.988)
ENROL1890FEM	-0.0252 (0.058)	-0.0208 (0.008)	-0.0209 (0.007)
Ln(GDPC1890)	0.0025 (0.750)		
GROWTH	-0.6295 (0.298)	-0.3274 (0.445)	
FER1890	0.0000 (0.889)		
FERCHANGE	0.0051 (0.151)	0.0049 (0.126)	0.0040 (0.167)
IMR1890	0.0000 (0.907)		
Adjusted R2	0.395	0.413	0.436
F-stat prob.	0.093	0.011	0.004
Observations	16	19	19

Note: See table 3; adjustment for share of female enrolment based on Lindert (2004: 95) consider Austria, Belgium, Bulgaria, France, Germany, Hungary, Italy, the Netherlands, Romania, Spain and Switzerland.

enrolments for eleven of the 19 countries in the model. For about half of the countries, the shares consider 1890-94 whilst the other half is by the end of the decade. However, since the aim of the adjustment cannot be to get a high precision but rather to see the direction of the effect, whether it corroborates the model or falsifies it. The adjustment factor is twice the female share of enrolment, meaning that a 45 per cent share only gives a 90 per cent count of the enrolment figure. For Northwestern European countries the adjustment is very small, which also reduces the bias from no adjustment at all for the Nordic countries or for Britain. The results are reported in Table 4 and do indeed corroborate the results from the original model. The most significant difference is the increase of the explanatory power, rising from 0.385 for adjusted r-squared in (4) to 0.436 in (4').

One should remember that these are estimations on national aggregates. Demographers usually ask for the underlying differences that make the picture more complex. Certainly that could be done also in this case but the point is that, despite all these regional, social, and demographic diversities, did the schooling factor have such a pervasive effect on the decline in infant mortality that it is manifest even in our crude aggregate data when applied in a cross-country comparative model. The low number of countries may evoke doubts about robustness but one could also say that despite the low number, the correlations are strong enough to yield statistical significance. The countries involved fairly well represent the European context which is the area considered.

Interestingly, recent research reports evidence for the importance of education also for the decline in infant mortality in developing countries in the post-1960 period. These findings further underline the supposed mechanism behind a behaviourial change by also taking account of quality in education as well as technical change (Jamison et al 2004; Jamison et al 2007).

VII. Concluding reflections

The paper began with the claim that Pasteur's germ theory represented a major discontinuity in human history, comparable both with the Neolithic and the Industrial Revolutions. Foremost it was its impact on infant and early child mortality with substantial effects on longevity, in other words, on living standards. However, the decline of infant mortality has been the subject of a long and inconclusive discussion. For sure, there is indeed a long list of factors that account both for the difference in levels as well as for the decline of infant mortality. However, the fundamental role of parental care, motherhood, or, with Mokyr, the technology of the modern household, is often passed over or mixed up along with the list of other factors. One could argue that Pasteur's discovery was typical for the era, with several other scientific discoveries and innovations that together ushered the second industrial revolution. Yet, this also highlights the point since the decline in infant mortality is as unthinkable without Pasteur as electrification without Siemens. And both are necessary elements in a development with sustained increase of longevity as well as economic growth.

The adoption of the germ theory in the society of *school hygiene* make plausible that elementary education became an effective tool for the diffusion of the new behavioural standards. Thus, the cross-country correlation between the decline in infant mortality and enrolment in primary education is clear empirical evidence for the impact of the germ theory. The argument is further corroborated by the, still if half-finished, adjustment for gender differences in school enrolment. On the other hand, the irrelevance, for the decline in infant mortality, of both the average income, economic growth, and the initial level of infant mortality indicates that a behavioural shift, on the level of the household, was a causal factor in the drop of infant mortality. This explains why this drop could occur at about the same time, from strikingly disparate levels and in very different environments.

Two further reflections are provoked by the findings. One is about how misplaced a strand of the feminist critique against the gender division of labour actually is. It has argued that the male bread-winner household relegated women to menial and dulling work in the home. How ignorant of both the need for new skills, in the household, and the contribution of this work for twentieth century development! It is amazing that when males are bound to work in industry, and seen as exploited by capitalists, they are recognised as productive heroes but when females are bound to work in the home, and exploited by husbands, they are of no importance, invisible in history and unproductive. It seems to be a failure of recursive history: the gender division of labour, which still today is a constraint, has hidden the progress and contribution of the technology of the modern household. One can acknowledge the latter and still oppose the gender division of labour.

The other reflection is also about the failure of recursive history: the idea that the demographic transition can be described as a choice of quality before quantity which moreover should be biologically inherent in humans of "type a" superior to humans of "type b" (Galor and Moav 2002). That idea is ignorant of the role of knowledge for historical development. It is an anachronism to imagine the decline in infant mortality, and the broadly concomitant decline of fertility, as a shift in taste more or less independent of the scientific revolution connected with the germ theory. The anachronism is further exacerbated by its combination in a historical stage theory, where the switch in taste from quantity to quality should unleash modern economic growth and put this whole history on a biological instead of intellectual basis.

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