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The lowest possible infant mortality rates in prehistoric and medieval populations discussed in the light of nineteenth-century northern European experiences

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Abstract

New historical demographic studies show that the infant mortality rates (IMR) were not uniformly high in the eighteenth and nineteenth centuries. The variability was huge. In some places the level was as high as 80 deaths in the first year of life per 100 live births; while the minimum observed was merely 7. This chapter discusses how this best practice was achieved and if it could have been equaled in prehistoric times. It concludes that exclusive breastfeeding the first five to six months followed by several years of combined breastfeeding and other sustenance were the essential elements when achieving this minimum IMR. Some prehistoric populations may have done that even if ideas about how to breastfeed correctly most probably have differed as much in prehistoric times as in the nineteenth century.

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It is common knowledge that in the bad old days before the hygienic and medical revolutions of the early twentieth century, infant mortality was excessively high. Therefore, whenever archaeologists excavating prehistoric and medieval burial places find only a low proportion of infant skeletons, they have to wonder why. Of course, infant skeletons may be missing for many reasons including easier dissolution of small, fragile skeletons and the disposal of dead infants in different places. However, the expectations as to the correct number of infant skeletons are often based on the high national averages of infant mortality rates (IMR) during urbanization in the late nineteenth and early twentieth centuries and on the descriptions of infant mortality in former times used by medical doctors in the middle of the twentieth century, when they looked back on declining mortality as one of the great triumphs of modern medicine. Their narratives often implicated a uniformly high infant mortality becoming even higher the further back in history one delved.

However, new empiric studies, carried out by historical demographers and historians during the last twenty years have shown that this familiar narrative does not comprehend the history of levels, trends and variables in infant mortality in the eighteenth and nineteenth centuries. The image that emerges now is much more complicated and less linear. More and more examples of local populations with unexpectedly low levels of IMR come to light. Norway and Denmark are countries which both have high quality data and are rich in low infant mortality regions during the nineteenth century.

In this article I shall discuss whether the more detailed knowledge of the existence of low infant mortality regions in the nineteenth century side by side with regions with much higher levels of infant mortal-

ity have insights to offer researchers working with infant mortality in pre-statistical times. I shall focus on three questions:

- How low was the lowest level of infant mortality in nineteenth-century northern Europe on a regional level before circa 1880, when modern knowledge about pathogenic microorganisms began to be integrated into birth assistance and infant care practices?
- How was this best practice carried out?
- Could this best practice have been performed in prehistoric times and could the resulting IMR have been as low as in the nineteenth century?

Background: The infant mortality rate (IMR)

The infant mortality rate (IMR) is the statistical tool used by statisticians and historical demographers to measure the frequency of infant death in a given population. It is defined as the number of deaths in the first year of life among 100 (or 1000) infants born alive. It is a very powerful concept, as it allows direct comparison of infant deaths between different populations, as the population at risk is always the same: the infants born alive and thus running the risk of dying. The invention and use of this concept was one of the most important stimuli to the onset of public health interventions to reduce infant mortality.[1]

It is important to keep in mind that in pre-parish register populations we almost never have access to the number of live- born babies. Therefore it is not possible to make a direct calculation of the IMR. Where the sources are burial places alone, it is only possible to calculate the distribution of age among the deaths. That is a quite different concept, which does not offer the possibility of comparing the frequency of infant death between populations, as the percentage of infant skeletons among all skeletons will differ according to the number of adult skeletons, even when the IMR is the same. Thus a high percentage of infant skeletons may be due to the fact that some of the adult members of the population had been buried elsewhere, as is often the case with warriors or sailors.[2] The proportion of infant skeletons at a burial place will also change when the birth rate in the living population increases or decreases, even if the IMR are constant. Thus a low number of infants buried could be due to few births just as well as to a low infant mortality.

Nevertheless, the age distribution among skeletons is the best available information we have for pre-register populations and valuable knowledge can be gained from it. However, in order to proceed from age distribution among the buried to infant mortality rate, some serious modelling is necessary. This includes careful methodological considerations about the fertility, mortality and burial patterns for the whole population. Such models have been made and have been used to calculate IMR[3], but some of the most-used models were calculated twenty-five years or more ago[4] or have used twentieth-century national aggregated level data.[5] They have therefore not had the possibility of including the more recent historical demographical studies in the great variability in IMR in the nineteenth century.

The infant mortality rate was not uniformly high in the past

The one most important result of the many recent historical demographic studies about IMR in the past is that in the two centuries preceding the onset of the large early twentieth-century decline all over Europe, the variability in the IMR was huge. IMRs varied from place to place both locally within countries and

1. Løkke, "No Difference without a Cause. Infant Mortality Rates as a World View Generator".

2. Løkke, *Døden i barndommen*.

3. Boldsen, "Patterns of childhood mortality in medieval Scandinavia".

4. Gejvall, "Westerhus. Medieval population and church in the light of skeletal remains", 38f; Boldsen, "Two methods for reconstructing the empirical mortality profile".

5. Gage, "Variation and classification of human age patterns of mortality: analysis using competing hazards models".

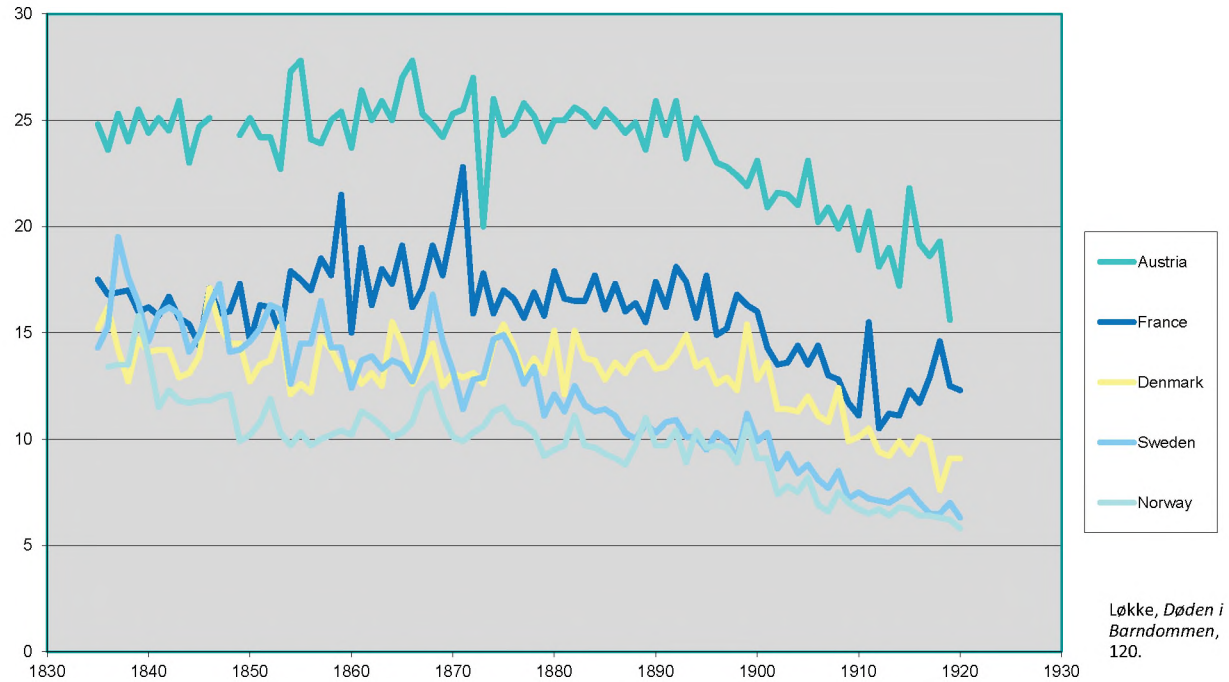
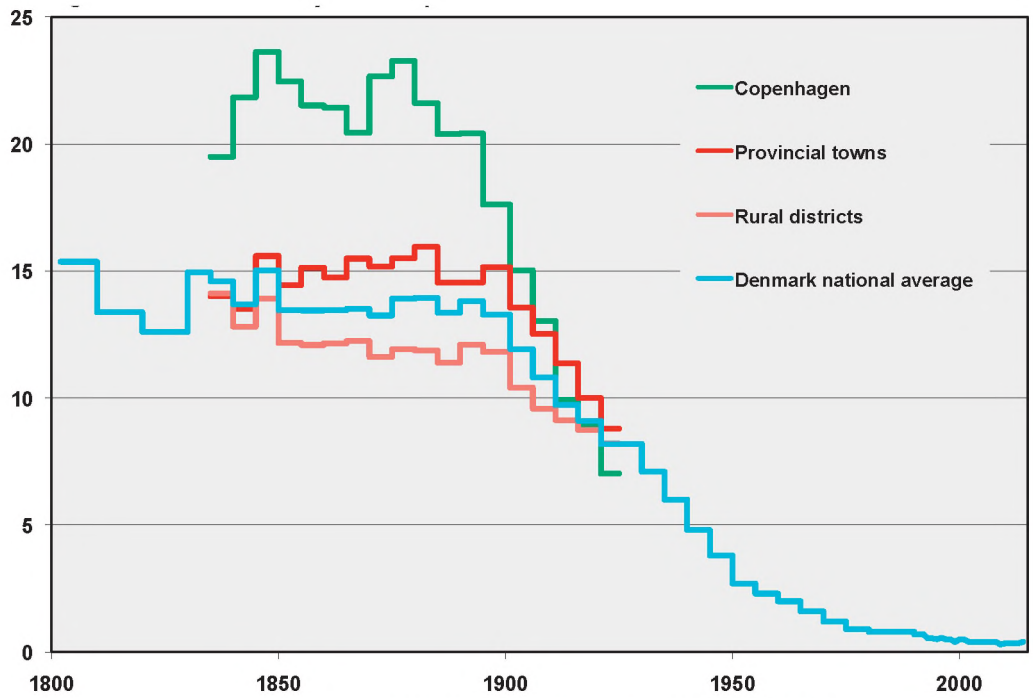


Figure 1. Deaths in the first year of life per 100 live births 1835-1920.

between countries. It varied between cities and countryside, between different cities and between different localities in the countryside. It differed between legitimate and illegitimate infants and between the social classes – most often in disfavour of the poor, but even that was not always the case.[6] Thus, when the twentieth-century decline sat in, it was not only a decline but just as importantly a transition from great variability to lesser variability.[7]

During the nineteenth century European regions existed where 50 percent or more of the live-born infants died before their first birthday and at the same time there were regions which kept the IMR down to 10 percent decade after decade.[8] Examples of places with very high IMRs are seen, in the eighteenth century, in northern Sweden[9] and in the marshlands in South-East England.[10] In the early nineteenth century Iceland[11] and Bavaria[12] had excessively high IMRs. Such high IMRs could also be found among illegitimate infants in Copenhagen in the 1860s and 1870s, where the IMR peaked at 55 percent, while infants born in wedlock in the same decades had a level at 20 percent.[13] Even higher levels, 70 to 80 percent were found on the island of Vestmannaeyjar in Iceland[14] and among illegitimate infants left at the Royal Foundling Ward in Copenhagen (*Den Kongelige Pleje-*

6. Edvinsson, Garðarsdóttir and Thorvaldsen, "Infant mortality": 463, Løkke, *Døden i barndommen*: 145, Wrigley, *English population history from family reconstruction 1580-1837*: 218-219.
7. Løkke, *Døden i barndommen*: 229-231.
8. Knodel and Van de Walle, "Breast Feeding", Løkke, *Døden i barndommen*: 157-179.
9. Brändström, *De kärlekslösa mödrarna*.
10. Dobson, *Contours of Death and Disease in early Modern England*: 340.
11. Garðarsdóttir, *Saving the child*.
12. Knodel and Van de Walle, "Breast Feeding".
13. Løkke, *Døden i barndommen*: 219-224.
14. Guttormsson and Garðarsdóttir, "Public Intervention to Diminish Infant Mortality from Neonatal Tetanus in the Island of Vestmannaeyjar (Iceland) during the First Half of the Nineteenth Century".



Source: Løkke, Døden i Barndommen, 120. Updated 1994-2014 based on Statistikbanken

Figure 2. Death in the first year of life per 100 live births in Denmark 1802-2014. Copenhagen, Provincial towns, Rural districts, The whole of Denmark.

stiftelse)[15], as well as at the Madrid Foundling Hospital (*La inclusa*).[16]

The lowest known relatively stable regional levels of IMR are found in some rural areas in Norway and Denmark throughout the nineteenth century. These levels are reliable, as both Norway and Denmark had established and well-kept registration practices. The lowest level of IMR in Denmark for decades in regions the size of Danish *herreder* (which normally consisted of six to ten parishes) remained at 10 percent for the whole population and 7 percent among the infants born in wedlock. [17]

The national IMR levels masked to some degree the regional variability, but even so also the national levels showed differences in a scale unseen in our time.

15. Løkke, *Patienternes Rigshospital 1757-2007*: 45.
16. Revuelta-Eugercios:, "Surviving the bottle: feeding practices and foundlings' health in 20th-century Madrid"", in *14th ICREFH Symposium. Food and life span in Europe 1800-2000*.
17. Løkke, *Døden i barndommen*: 137-147.

During the nineteenth century the national average IMRs in Norway, Denmark, and Sweden were the lowest in Europe, although the registration there was among the most reliable. Norway held an absolute low with a national average IMR at 10 to 12 deaths per 100 live-born 1840-1880 and 9-11 percent for the rest of the century. Denmark held a level at 13-15 percent throughout the century, while France (and England and Wales) held levels a little higher at 15-17 percent. In Europe the high position was occupied by Austria, Bavaria and Iceland, which held IMR averages of 25-27 during most of the nineteenth century. Only Austria is shown in figure 1.

The infant mortality has varied over time in non-linear ways.

During the late nineteenth and the twentieth century the IMR at the aggregated national average for most countries presents itself as a continuous decrease. This may give the impression that the IMR in the

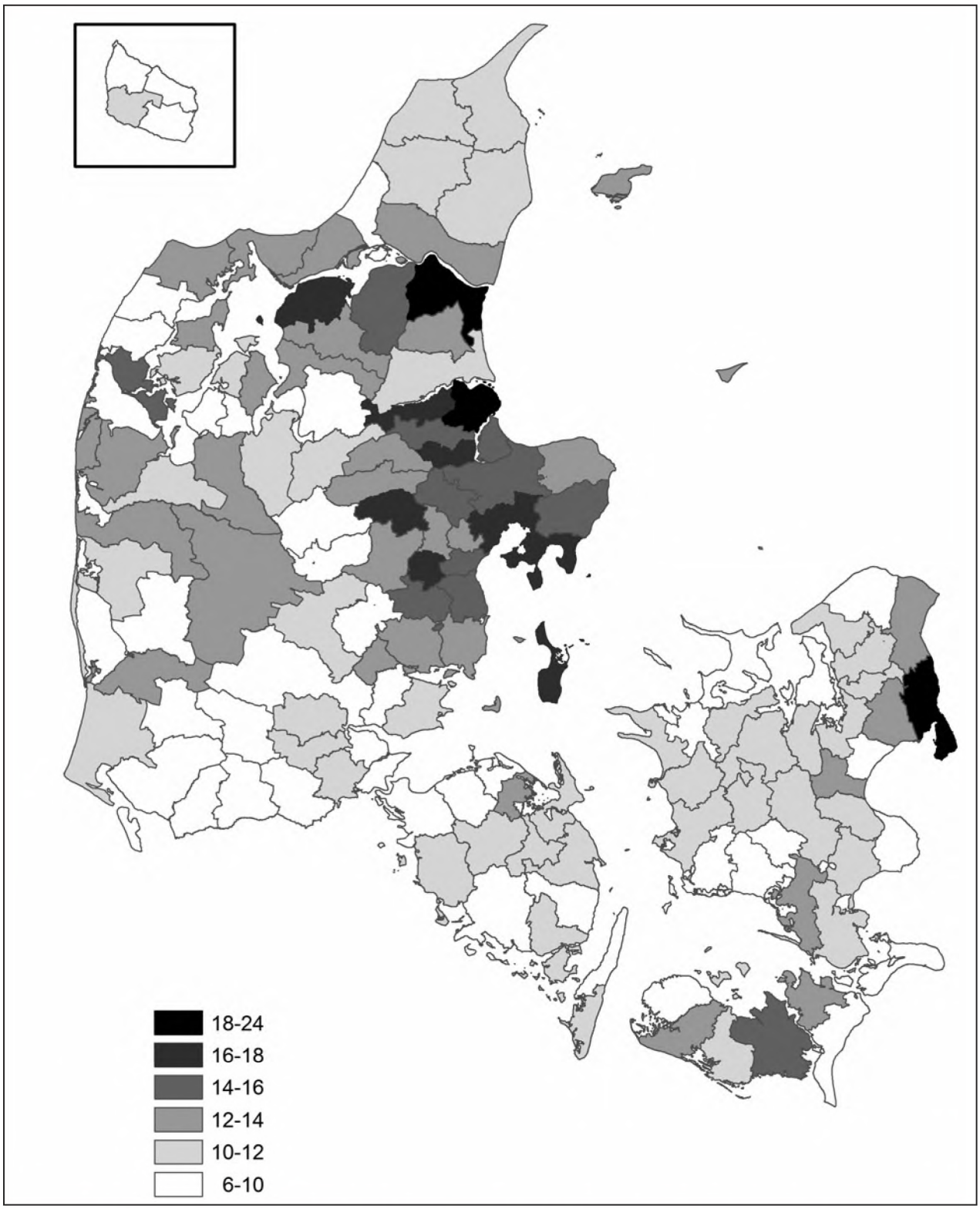


Figure 3. Danish rural districts 1850- 1854 divided into *herreder.* Death in the first year of life per 100 live births.
Source: Løkke, *Døden i Barndommen:* figure 2.10 144 II and appendix 2.3b. Map redrawn by Peder Dam/www.digdag.dk.

more distant past was as high as in the late nineteenth century or most probably higher. Recent studies show, however, that the IMR has been highly variable before the great early twentieth-century decline. This is not easily understood, as the aggregated national level often masks several increases and decreases at regional and local levels for different reasons.

An example of this is the Danish case (Figure 2): The stable national IMR of around 14 percent between 1850 and 1900 is not homogenous when subdivided. The stable national IMR masks that the rural districts had a lower level with a slow decrease, the provincial towns a slightly higher level with a slow increase and that Copenhagen, Denmark's only metropol, went through a rather turbulent development at a much higher level with two steep increases followed by decreases. Such increases in big cities were common all over Europe and are explained as a crisis of urbanization, when the population increased rapidly while sanitation remained miserable. Also in Copenhagen investments in clean-water supply, more hygienic dealing with night soil, the building of an underground sewerage system and introduction of prevention and control measures related to food-borne hazards have all played a part in the declines.[18] Rapidly growing cities in the nineteenth century seem nearly everywhere to have experienced increases in their IMR.

However, even the low IMR in the rural areas varies considerably from place to place from 6-10 percent in the *herreder* with the lowest IMR to 18-24 percent in high IMR *herreder* (figure 3).

The levels and time trends in the IMR are generally not known for periods earlier than the nineteenth century. To establish knowledge further back in time, IMRs have to be calculated from parish registers, which involves a huge work load and is thus not yet universally done. An impressive study, however, has been made in this way by Wrigley et al., who have studied the long-run trends in IMR in England and Wales among legitimate infants from 1580 to 1837. They see for sub periods during this time several increases and decreases: Rising from medium to medium high, decreasing to medium again, and then decreasing to medium low.

Table 1:

	Number of deaths in the first year of life per 100 live-born in England
1580-1679	16,4 (of these 1620 to 1649 as low as 15,5)
1680-1749	19,0 (of these 1680-9 and 1710-9 were above 20)
1750-89	16,3
1790-1837	14,1

[19]

A more detailed analysis of the distribution of deaths over the first year of life shows that the number of deaths in the first month of life went down, while in the second half of the first year the mortality in 1825-37 more than doubled compared to the level before 1675. This means that different variables had been involved in the composition of the IMR at different times.[20]

What is influencing the level of infant mortality?

Many studies have shown that a broad range of variables influence the level of IMR, among them economy, feeding practices, climate, population density, hygienic environment, illness panorama, legitimacy, order of birth, confession, age of parents, and many, many more. Several attempts have been made to order factors known to influence the IMR in a hierarchy, but they seem to escape that kind of ordering, as there are nearly always many factors at work at the same time, and they often produce a synergetic effect.[21]

To comprehend the interlinked nature of the variables influencing the level of the IMR, I have argued

18. Løkke, *Døden i barndommen*: 201-204.

19. Wrigley, *English population history from family reconstruction 1580-1837*: 218-219.

20. Wrigley, *English population history from family reconstruction 1580-1837*: 223.

21. Løkke, *Døden i barndommen*: 125-127.

that a model that analyzes the level of the IMR as an unstable balance between resistance and exposure is fruitful, as this model makes it clear that the same level of IMR in two populations does not have to be caused by the same factors. The same build-up of resistance will give a different IMR output if the exposure is changed and vice versa.[22]

Very high levels of infant mortality show up in empirical studies, when the resistance build-up was minimal and the exposure to one or more high risk factors was great. The minimal resistance build-up is most often caused by no breastfeeding at all right from birth.[23] Other factors known to hamper resistance build-up in infants are severely under- or malnourished mothers during pregnancy and a high incidence of pre-term infants for example as a result of hard workloads for the mothers during pregnancy. Exposure can be increased in many ways. Among the most fatal in nineteenth-century northern Europe was infant diarrhoea caused by unhygienic urban environments and unclean feeding utensils and sustenance[24]. Epidemic diseases such as measles, whooping cough and diphtheria played a part[25] as well as endemic illnesses. Endemic tetanus kept the IMR over 70 percent in the early nineteenth-century Icelandic island of Vestmannaeyjar and malaria caused the high levels in the English marshlands.[26]

How was the minimum level of Infant Mortality achieved?

The Norwegian and Danish minimum levels of IMR in the nineteenth century were achieved in regions, where the exposure was minimal according to the standards of the time and the resistance build-up was maximized.

The concrete processes involved were several. The minimum exposure was found in rural districts which were then called healthy areas. This means that severe illnesses such as malaria or tetanus were not endemic, that the panorama of less malign infectious diseases was relative stable so the mothers had a high probability of having gained immunity from them and that epidemics malign for infants did not have easy access to the place. That was often the case where no larger town or city was nearby and no main road or trafficked harbour was within easy reach.

In addition vaccination against smallpox was very widely accepted in Denmark from the early nineteenth century, so the exposure to smallpox of infants not yet vaccinated was thereby reduced.

It was also the case that in minimal IMR-regions the prevalence of restricted pelvis hampering births as a result of rickets in the childhood of the mothers, was less than in high mortality regions, so births were easier and less dangerous for the infants (and the mothers).[27]

And as a last variable reducing IMR, a network of educated, authorized midwives, midwives free of charge for the poor and used by rich and poor alike, was introduced in Denmark from the early nineteenth century and in full function in the 1840s. The midwives were trained to keep the birth normal so as to avoid procedures dangerous for mother and infant. The result was a significant decrease in perinatal and maternal mortality that remained lower than in most other countries until antibiotics were introduced worldwide in obstetric care from the 1930s.[28] There are sources telling of a singularly competent midwife at one place or another from many periods in history, but it was not until the late eighteenth century that

22. Løkke, *Døden i barndommen*: 128-129.
23. Knodel and Van de Walle, "Breast Feeding", Løkke, *Døden i barndommen*: 157-179, Garðarsdóttir, *Saving the child*.
24. Løkke, *Døden i barndommen*: 62-64.
25. Løkke, *Døden i barndommen*: 196.
26. Dobson, *Contours of Death and Disease in early Modern England* 340, Guttormsson and Garðarsdóttir, "Public Intervention to Diminish Infant Mortality from Neonatal Tetanus in the Island of Vestmannaeyjar (Iceland) during the First Half of the Nineteenth Century".
27. Løkke, *Døden i barndommen*: 139-183.
28. Løkke, "The antibiotic transformation of Danish obstetrics. The hidden links between the decline in perinatal mortality and maternal mortality in the mid-twentieth century", Løkke, "Did midwives matter? 1787-1845".

there were organized endeavours to train every midwife in best practice.[29]

But even with the minimal exposure possible in the nineteenth century the IMR could vary greatly. The minimum IMR levels of 7 percent were only reached for infants born in wedlock in populations who carried out breastfeeding in a special way.

The maximum resistance needed for the minimal IMR was carried out by extended breastfeeding with well-timed introduction of complementary feeding

Breastfeeding can be carried out in many ways with different results for the resistance build-up. The local populations in nineteenth-century Denmark who maintained the minimal IMR, breastfed exclusively for five to six months. That means that nothing but women's milk direct from the breast was given to the infant until it was old enough to sit on a grown up's lap and grab its food for itself. Then followed two, three or more years in which the infant continued to suck but also received complementary food from the table.

In the Danish high IMR regions breastfeeding was also almost universal, but it was carried out in another way. The crucial difference was the timing of the introduction of complementary feeding. In the populations which gave complementary foods alongside the breast right from birth the IMR was doubled to a level of 18-20 percent even in healthy areas. The breast/food combination, which is healthy for infants six months old, can be fatal for a new-born baby.[30]

The description and understanding of these nineteenth-century infant feeding cultures has been complicated by the early to mid- twentieth- century medical doctors, who did not use a language that was able to distinguish between exclusive breastfeeding and breastfeeding with complementary sustenance. They found the long period of combined breast and food disgusting and prescribed breastfeeding followed by, what they called "weaning", by which they meant a period not longer than a month going from breast milk only to no breast milk at all.[31] This has in turn given a lot of misunderstandings in the research about breastfeeding both in medical science and among historical demographers. The problems have until recently been that very often it has been impossible to see whether the word breastfeeding was used for "exclusive breastfeeding" or for "breastfeeding with complementary feeding" or for both. The word "weaning" too has been used for at least three different processes. As a long period of breastfeeding with complementary feeding is today seen by paediatricians as the best for infants over six-months-old, the concepts used now are "exclusive breastfeeding", "breastfeeding with complementary feeding" and "no breastfeeding". The term "weaning" is avoided because of its lack of precision and lack of recognition of the desirability of a long period of breastfeeding with complementary food.

Today pediatricians explain the better survival of infants who are exclusively breastfed for the first six months of life compared with entirely artificially fed, everything else being equal, with four points:

- The breast milk shall not be handled. So it is not exposed to contamination on its way from breast to baby.
- The breast milk meets automatically the nutritional needs of young infants, also the ones science have not discovered yet.
- The breastfed infants do not receive substances harmful or useless for it.
- Through the breast milk the infant gains access to the immune system of the mother and the development of the infant's own immune system is stimulated.[32]

The excess mortality of artificially fed infants is highest where the hygienic conditions are worst, where knowledge of suitable substitution is poor and where poverty places obstacles to the obtaining of such substances.

29. Løkke, "The 'antiseptic' transformation of Danish midwives, 1860-1920".
30. Løkke, *Døden i barndommen:* 130-34.
31. Løkke, *Døden i barndommen:* 259-73.
32. Akre, *Infant feeding*: 31.

Experiences from early twentieth- century pediatricians as well as later tropical pediatricians agree that exclusive breastfeeding for the first six months followed by extended breastfeeding alongside other sustenance for some years is a very effective way of preventing high IMR in poor populations living in unhygienic environments.[33] The Swedish state was organizing public health interventions based on knowledge about this as early as the late eighteenth century, when midwives and a physician were sent to Nedertorneå in Northern Sweden to teach the mothers how to breastfeed in order to bring down the excessively high IMR. The local tradition was to give the infants milk from animals served through a cow's horn. The campaign succeeded as the IMR went down, but the mortality among children from one to four years old went up.[34] A development pointing to the possibility of mortality regimes in the past with life tables as different from the European twentieth-century life tables as the ones found by Gage in African and Asians populations in the middle of the twentieth century.[35]

To sum up - the level of infant mortality can fruitfully be seen as a balance between exposure and resistance. A major part of the resistance build-up is determined by nutrition. In nineteenth- century Denmark and Norway the minimal IMR of 7 percent was reached by exclusive breastfeeding during the first five to six months of the infant's life followed by step by step introduction of other sustenance alongside breastfeeding for two, three or more years. Even in years of epidemics the IMR in these minimum IMR regions did not reach the average level for *herreder* where the infants were given supplementary feeding to the breast right from the birth. Only the war year 1849 brought the IMR up to the 22 percent, which was quite normal in places where extra substance was given from the birth.[36]

33. Løkke, "Liv og død på dåse. Markedet for industrielt fremstillet modermælkserstatning og amning i verdens fattige lande, Skandinavien og USA i det tyvende århundrede".
34. Brändström, *De kärlekslösa mödrarna*: 167-171.
35. Gage, "Variation and classification of human age patterns of mortality: analysis using competing hazards models".
36. Løkke, *Døden i barndommen*: 175-176.

Conclusion

The IMR has not been homogeneously high in historical populations and the changes over time have not been linear. Is it possible, then, that the IMR in some prehistoric and medieval populations can have been as low as the mid-nineteenth-century minimum level? A level which was 7-10 deaths in the first year of life per 100 live births.

On the resistance side, it should not have posed more problems for prehistoric and medieval mothers to breastfeed than it did for nineteenth-century mothers, given that their ideas of proper infant feeding were exclusive breastfeeding for five to six months followed by breastfeeding with complementary food for two or more years.

On the exposure side it is more complicated: In the sparsely populated areas in prehistoric times the chances are that exposure to epidemic diseases and other infections could be even smaller than in healthy rural areas in nineteenth-century Denmark. In the middle ages, however, there must have been as great a variation in exposure levels as in the nineteenth century, so the IMR there must have differed as much from place to place and over time as in later times. And most likely even more so, as the plague was intermittent in Denmark until 1711 and smallpox vaccination was not performed until the early nineteenth century. Even so, it is not unreasonable to think that there were rural localities which could have escaped severe epidemics for a generation or two.

What was missing in prehistoric and medieval times compared with nineteenth-century Denmark was the presence of midwives who were effectively trained to keep normal births normal and who attended to births in all parts of the population. Therefore, a higher perinatal mortality must be expected in prehistoric and medieval populations on an average. This does not, however, exclude that some gifted midwives at some places may have been able to keep the perinatal mortality low.

Thus, the overall result is that given that a prehistoric, rural population was fairly well nourished, had a breastfeeding-friendly culture, lived in a healthy

place without severe endemic infections such as malaria, tetanus and smallpox or easy access for epidemics, and had an unusually gifted midwife, the minimal IMR should not need to be more than the 7 to 10 percent experienced in some rural parts of Denmark and Norway in the nineteenth century.

It is, of course, most likely that other ideas on infant feeding were dominant in other prehistoric populations as they were in nineteenth-century populations, which caused higher levels of IMR. The same goes for all kinds of variables enlarging the exposure. Therefore, it must be expected that the variation of the IMR between places and over time in prehistoric and medieval times must have been as large as in the nineteenth century. This means that some populations could have had an IMR as low as 7 to 10 percent for a generation or more, while populations nearby due to negative ideas about breastfeeding combined with high exposure could have had levels up to 70-80 percent. So no easy model can be applied as to how many infants' skeletons there need to be at a burial place to suggest that no dead infants are missing. On the other hand, few infant skeletons at a burial place could be a sign of a demographical pattern with low infant mortality due to a resistance-building breastfeeding pattern. It is possible to work with this hypothesis using stable isotope analysis on teeth from skeletons of adults, as the teeth provide the isotopic signal of the dietary protein consumed as infants and young children and thereby indicate whether they have been breastfed and if so for how long.[37]

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