The relationship between stillbirth and early neonatal mortality: evidence from eighteenth century London [1]

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Introduction

The first day of life is the most dangerous. Mortality declines from the point of birth throughout the first days of life and generally continues to decline until late adolescence. Figure 1 provides examples from several populations, with infant mortality rates ranging from 44 to 218 deaths in the first year of life per thousand births. The data in Figure 1a are from a modern Indian population, with moderate infant mortality by historical standards (71/1000). The death rate was nearly five times higher on the day of birth than subsequent days. On a finer time scale, in data from the Egyptian Demographic and Health Survey in 2000 (Figure 1b) the death rate in the second hour of life was only two-thirds that of the first hour, and dropped dramatically over the first 24 hours of life. These data are from modern populations, where infant mortality is increasingly concentrated in early infancy, so they may exaggerate the relative dangers of the first day of life. However the trauma of birth, and the challenges posed to newborns by the extra-uterine world, have always made the first hours and days of life uniquely dangerous. Figure 1c shows the daily death rate for infants born in three 'healthy', predominantly rural counties and in three particularly unhealthy urban areas in England in the late nineteenth century, when infant mortality rates were comparable to those of the late eighteenth century. Again, mortality was three times higher on the first day than on the second or subsequent days after birth, in both populations.

The period of life with the highest mortality rates is also the one we know least about, and this is particularly true of historical populations. Apart from under-reporting of early infant deaths that escaped baptism, there is also a basic problem of definition. Deaths particularly in the first hours of life occur in a liminal phase, where the distinction between live-born infant and stillborn foetus may be very slight. The difficulty of distinguishing live-born from stillborn is reflected in the difficulty of drafting early legislation requiring the registration of stillbirths – what signs of life are sufficient? Heartbeat, pulsation of umbilical cord, inspiration, crying? More problematically, many societies did not draw any such rigorous distinction. For instance, in France, Belgium and the Netherlands, under the influence of the Napoleonic Code in the nineteenth and early twentieth centuries, any deaths occurring before registration (in practice up to three to five days after birth) could be considered stillborn, and therefore discounted from infant mortality statistics.

The current World Health Organisation definitions are shown in Table 1. Although stillborn deaths are now clearly distinguished from deaths in the first hours after birth,

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in fact the two types of mortality are often very similar, with common aetiologies. The term perinatal mortality recognises the basic unity of stillbirth and early neonatal deaths. The causes of perinatal mortality remain incompletely understood. Pre-partum stillbirths, those occurring before labour, may reflect genetic or gestation conditions, including maternal nutritional status, and exposure to infection and toxins during pregnancy. Intra-partum deaths, those occurring during the birth process, can reflect the circumstances of the birth (including position of the foetus, multiple births, premature delivery, placenta praevia, pelvic deformations and accidents due to interference). Intra-partum deaths may also be caused by the same conditions causing pre-partum deaths. For instance, inadequate placental supply results in foetal growth restriction. These foetuses may die in the late stages of pregnancy as the placenta becomes unable to supply adequate oxygen and nutrients, or they may survive gestation, but be too weak to survive a long labour. Causes affecting intra-partum mortality are also the main causes of early neonatal mortality. Therefore perinatal mortality is an important indicator, with maternal mortality, of maternal health and birthing conditions, and may show quite different trends from infant mortality at other ages, even within the first month of life.

What do we know about perinatal mortality in the past? Bob Woods has recently produced a masterful summary of historical stillbirth mortality, in his book 'Death before Birth'. He uses two main sources for estimating historical stillbirth rates. These are: recorded stillbirths, in the rare cases where these exist, and; the early neonatal mortality rate. Bob Woods prefers the early neonatal mortality rate, because it is closely related to the stillbirth rate in modern populations, and because it is more widely available and more reliable than the stillbirth rate. An obvious problem of course is that both these sources, stillbirths and early neonatal mortality, will be affected by problems of classification. For instance, Roger Schofield used recorded stillbirths from the widely dispersed Lake District parish of Hawkshead, to calculate stillbirth rates for the period 1581-1710, on the assumption that these were accurately recorded, at least for most of the period (Schofield, 1970). However Roger Finlay showed subsequently that stillbirths were most frequent in outlying areas of the parish, furthest from the parish church (Finlay, 1980). He argued that many of these stillbirths were in fact early neonatal deaths, of infants who had died before they could be brought for baptism. This type of under-recording of early neonatal deaths can cause significant underestimation of the infant mortality rate, under some circumstances. However a more serious problem is that both stillbirth rates and neonatal mortality levels and trends will be inaccurate. Since trends in neonatal mortality are often used as indicators of maternal health and environmental influences, large biases in the recording of neonatal deaths are problematic.

One way to assess the extent of mis-recording of early neonatal deaths is to assess the age distribution of infant deaths in relation to recorded stillbirths. Such data are very rare, but we have a large dataset of this type for the London parish of St. Martin-in-the-Fields, for the period 1750-1824. The data derive from the sextons' burial books, which recorded the cost and other details of burials in the parish. They also recorded the name, street address, sex, cause of death and exact age of the deceased. In the case of infants, age at death was recorded in days, weeks and months, and burials of both stillborns and 'abortives' were recorded in detail. The parish was very large, with roughly 1,000 burials per year, and comprised around 5% of all burials recorded in the

London Bills in this period. We have only included in our analysis those years where more than 95% of all burials gave exact age.

Stillbirth and early neonatal mortality in St. Martin-in-the-Fields

When the ages of infant death are plotted on a log scale (a Bourgeois-Pichat transformation), deaths in the first week of life constitute only eight percent of infant deaths, and those on day one are only five percent of *neonatal* deaths. For comparison, the Cambridge Group reconstitution results for roughly the same period are shown on the same graph (Figure 2a). Now, it is difficult to predict what the age distribution of deaths should be for a given population. It may well be that neonatal deaths indeed constituted a smaller proportion of infant deaths in London than in the predominantly rural Cambridge Group sample. Moreover the Cambridge Group sample will tend to over-represent early neonatal mortality, because of the measurement of age from baptism rather than birth, and the inclusion of 'dummy' births in first day mortality (Wrigley et al., 1997). There was some age heaping on weeks and months in the St. Martin's burials, but we have allocated burials so as to maximise early mortality (by assigning all burials of 'week old' infants to early neonatal mortality). Nevertheless, the apparent deficit in especially early neonatal deaths in the St. Martin's population is striking. Of course, it is not particularly surprising that a London parish should show a deficit of burials of newborns, because these are exactly the ages most liable to omission from both baptism and burial registers. However, it is very difficult to reconcile this paucity of early neonatal burials with the superabundance of stillbirth burials. Stillborn and abortive burials were equivalent to over 20% of live-born infant burials. If parents were lax in their reporting of newborn deaths, they appear to have been extraordinarily scrupulous with respect to the interment of stillborn babies.

The obvious conclusion is that some or most of the stillborn burials in St. Martin's were in fact early neonatal deaths. When all stillborn and abortive burials are added to both the burials and births, the age distribution of infant deaths closely resembles that of the Cambridge Group sample (Figure 2b). First day mortality is exaggerated, because all stillborn burials were added to the first day of life, whereas stillborn burials could well have included infants that survived for longer than a day. The data shown are for the period before 1775. The same pattern, of a deficit of early neonatal deaths, and a surfeit of stillborns, is also evident in the data for the quarter centuries before and after 1800. While it is unlikely that all stillborn burials were in fact early neonatal deaths, it seems very likely that many early neonatal deaths were buried as stillborn.

Another way to approach the problem is to compare stillbirth and early neonatal rates. We can't calculate accurate rates of infant mortality yet[5], but we can use baptisms as the denominator to compare stillbirth and early neonatal mortality rates in the parish.

[5] For two reasons: the under-registration of births apparent in the baptism series, and the market in burial spaces that operated in London in this period. Corpses were imported and exported for burial across parish boundaries, and, in contrast to parish registers, this traffic is recorded in the St. Martin's sextons' books, through the addresses of the deceased, and, after 1766, the fee levied on corpses before export. Before 1767 exported burials were not recorded, and therefore death rates will be underestimated in this period. From 1767 we can distinguish all burials by origin, and derive accurate estimates of burials of St. Martin's residents. Stillbirths were almost never imported or exported, and so the stillbirth rate is unaffected by these movements. We propose to partially reconstitute the parochial population, to improve our estimates of infant mortality, and to model the linkage rates of infant burials and baptisms estimate the extent of baptismal under-recording.

The neonatal mortality rate for the parish is very modest by contemporary standards (compared here with the Cambridge Group reconstitution sample for the same period), although the total infant mortality rate, calculated the same way, is well over 300/1000 (Figure 3). Again, this is unsurprising in an urban parish in this period, given the widespread under-recording of especially early infant deaths. However the stillbirth rate is much higher than expected. It is above the range predicted by Bob Woods, of 20-60 per thousand births, and well in excess of the stillbirth rate predicted from the early neonatal mortality rate using Woods' preferred estimation method.[6] What is also striking is the divergent behaviour of the two series. Early neonatal mortality appears to decline over the period, whereas the stillbirth rate fluctuates dramatically, and only shows convincing decline after around 1810.

If we accept that a large proportion of stillborns were in fact live-born, at least in the case of the parish as a whole, then the question arises as to why. While there may be difficulties in distinguishing live from dead infants in some cases, the enormous excess of stillborn burials over early neonatal suggests some more systematic process. One possibility, that we can explore using this dataset, is whether a financial motive existed to bury newborn infants as stillborn. The sextons' books included burial fees, and we have a schedule of fees for St. Martin's from around 1725. This list a lower price for 'Stillborn and Chrisom' than for other infants, and a lower price still for 'Abortives'. Therefore a financial motive existed to bury live-born infants as stillborn (or Chrisom). The term 'Chrisom', or unbaptised child, occurs only very rarely in the St. Martin's records, and there seems to have been no incentive to describe a child as Chrisom rather than stillborn, despite the apparent equivalence in burial price.

Although we have information on burial fees paid for stillborn and neonatal burials, it is problematic to address the question of a financial motive for choosing a stillborn burial. Despite the fee schedule, stillborn burials attracted a range of fees (Table 2). Interestingly, although there were more pauper burials of stillborn infants, nearly 60% of stillborn burials were well within the range of neonatal burial costs. Abortive burials on the other hand were almost never pauper, but were almost exclusively cheaper than other burials.

If poorer parents chose to bury their dead neonates as stillborn, then this should inflate the average cost of early neonatal burials. This is because those who *did* bury their neonates as neonatal deaths should have been richer on average, and therefore paid more for burial, than those burying older infants, who were more likely to be representative of the wealth range within the parish. Indeed, early neonatal burials did include a slightly higher proportion of high cost burials than later neonates (Figure 4). However the differences are relatively small. Moreover, the proportion of pauper burials was the same for early and late neonatal burials. In the case of paupers there was probably no financial motive to bury infants as stillborn, if the fee was zero in both cases. Therefore we might expect pauper burials to comprise a higher proportion of early neonatal than late neonatal deaths, if paupers were not subject to the same financial incentives to choose stillborn burial.

[6] Note that while under-registration of births would result in over-estimation of the stillbirth rate, any correction for under-registration of births would further deflate the very low early neonatal mortality rate.

The evidence is very inconclusive, but does not lend strong support to widespread concealment of early neonatal deaths as stillborn for financial reasons.

We can briefly examine two other possible explanations for the misclassification of early neonatal deaths as stillborn. One is the avoidance of the burial of an unbaptised child, perhaps for reasons of social stigma. It is very difficult to assess such a motive, particularly if private baptisms were common. The baptism records for the parish include date of birth as well as baptism, but so far we have only transcribed two years of data, for 1760 and 1795. In these years the delay between birth and baptism was such that fewer than twenty percent of those infants who were eventually baptised were baptised in the first week of life, and the delay lengthened considerably between 1760 and 1795. Furthermore, there was no evidence that infants that died were baptised any earlier than survivors (Table 3). Therefore there was a great risk of unbaptised infant death, and on the face of it little effort seems to have been made to avoid any attendant social stigma.[7]

A third possibility is that there was a widespread 'fuzziness' surrounding the definitions of stillbirth and live-born. The distinction *was* made in law, and was important in infanticide cases in the eighteenth century, when the defence was often that the dead infant was stillborn rather than murdered. Various tests were employed to determine whether the dead infant had breathed, and could therefore be considered live-born (Cody, 2005: 273-5). However a number of examples from the sextons' and parish workhouse records indicate that the sextons at least did not take such a rigorous view. In four cases, infants were listed as born in the workhouse, and as having died after one to three days, but were buried as stillborn according to the sextons' records. Another entry describes the burial of a 'Chrisom Child', aged 'four hours', but described as stillborn at burial. While these examples are few, they may be indicative of a more widespread blurring of the distinction between foetal deaths occurring in the process of labour, and deaths of very frail infants in the hours and days immediately following birth.

The workhouse records of admissions of discharges provide suggestive evidence of a change in policy with respect to stillbirths in the last quarter of the eighteenth century, that may have operated to bring workhouse practices into line with the prevailing legal definitions of stillborn. Before 1774 stillborns from the workhouse appear frequently in the sextons' burial records, but disappear after this date. Stillborns continue to be recorded in the workhouse admissions (after a hiatus in recording of stillborns in the period 1774-83), but apparently were no longer buried after 1773. This change in practice appears to have coincided with several changes in the age distribution of early neonatal deaths in the workhouse (Figure 5). Before 1773 there was a clear deficit in first day deaths, compared with the expected gradient in mortality with age. Deaths on the day of birth were *lower* than on subsequent days, suggesting under-recording of very early neonatal deaths.[8] There was also a striking peak of mortality at days 8-10, very typical of neonatal tetanus (sometimes called the

[7] We cannot assess the extent of private baptism, which have been especially common in cases where infants were deemed unlikely to survive. However private baptism was more expensive than church baptism, and is unlikely to have been practiced across the social scale.

[8] Although the numbers are small, deaths on day one would be expected to be at least three-fold higher than the days immediately following, so the deficit is too large to be attributable simply to statistical fluctuations.

'eight day disease'). After 1783, when stillborns were regularly recorded in the workhouse but were no longer buried, the distribution of deaths in the first week conforms to expectations. Overall infant death rates dropped markedly in the first month of life after 1783, *except* on the first day of life. Additionally, the mortality hump in the second week is greatly diminished, suggesting some change in delivery or after birth care that reduced the risk of neonatal infection with tetanus. Interestingly, the rise in the number of early neonatal deaths coincided with a rise in the stillbirth rate in the workhouse, from 73 (in 1760-73) to 104/1000 births (in 1784-99). Taken together this evidence suggests that a proportion of early neonatal deaths were recorded as stillborn in the workhouse before 1774, and that many genuine stillbirths were probably not. After 1783 both stillborn and first day deaths appear to have been recorded with greater accuracy, raising both rates.

Implications

The implications of the mis-recording of early neonatal deaths as stillborn depends to some extent on *why* it occurred. If it reflects the stigma of burial of unbaptised neonates, or some financial pressure, then the problem is unlikely to be significant for well-documented parishes where baptism occurred rapidly after birth, and where deaths were scrupulously recorded. The consequences are more serious if the practice reflects a general popular 'confusion' regarding the definition of stillborn. In this case even very high quality parochial records will suffer from under-enumeration of early infant deaths. Early neonatal mortality will be under-estimated, and therefore stillbirth rates derived from these. Conversely, where stillbirths *were* recorded, these may provide a very poor guide to levels of stillbirth mortality.

Does this matter? If stillbirth and neonatal mortality tend to move in tandem, then the omission of some proportion of deaths may distort the measurement of mortality levels, but not trends. However, this was not the case in St. Martin's. Stillbirth rates fluctuated apparently independently of the early neonatal and neonatal mortality rates. This is also evident in the stillborn and abortive burial series reported in the London Bills (Figure 6). Over the period when infant mortality as a whole appears to have dropped dramatically in London, stillbirth rates show little trend, at least before 1800. Similarly the Swedish stillbirth rate, recorded nationally from 1750, also rose in the last quarter of the eighteenth century, and bore little resemblance to the general trend in infant mortality (Woods, 2009: 68). These patterns may simply reflect the vagaries of recording or interment practices with respect to genuine stillborns. Alternatively, they could indicate some uncoupling between trends in death rates in the first hours of life, and deaths that occurred later in the first week of life, when infections may have begun to make a significant contribution. Such a distinction between stillborn and first day deaths on the one hand, and deaths later in the first week of life in the other, are evident in twentieth century data, and raise questions about the utility of the existing perinatal concept (Cross, 1973; Whyte, 1992). More critically, they may undermine the current use of the early neonatal mortality rate to predict stillbirths (as proposed by the WHO and Woods), especially in high mortality settings where there may be significant under-recording of first day mortality. We are currently applying for funding to partially reconstitute the infant population of St. Martin's, and to measure infant mortality by baptism fee. This should allow us to test more thoroughly the relationship between early neonatal mortality and stillbirths, and also whether it varied by social status.

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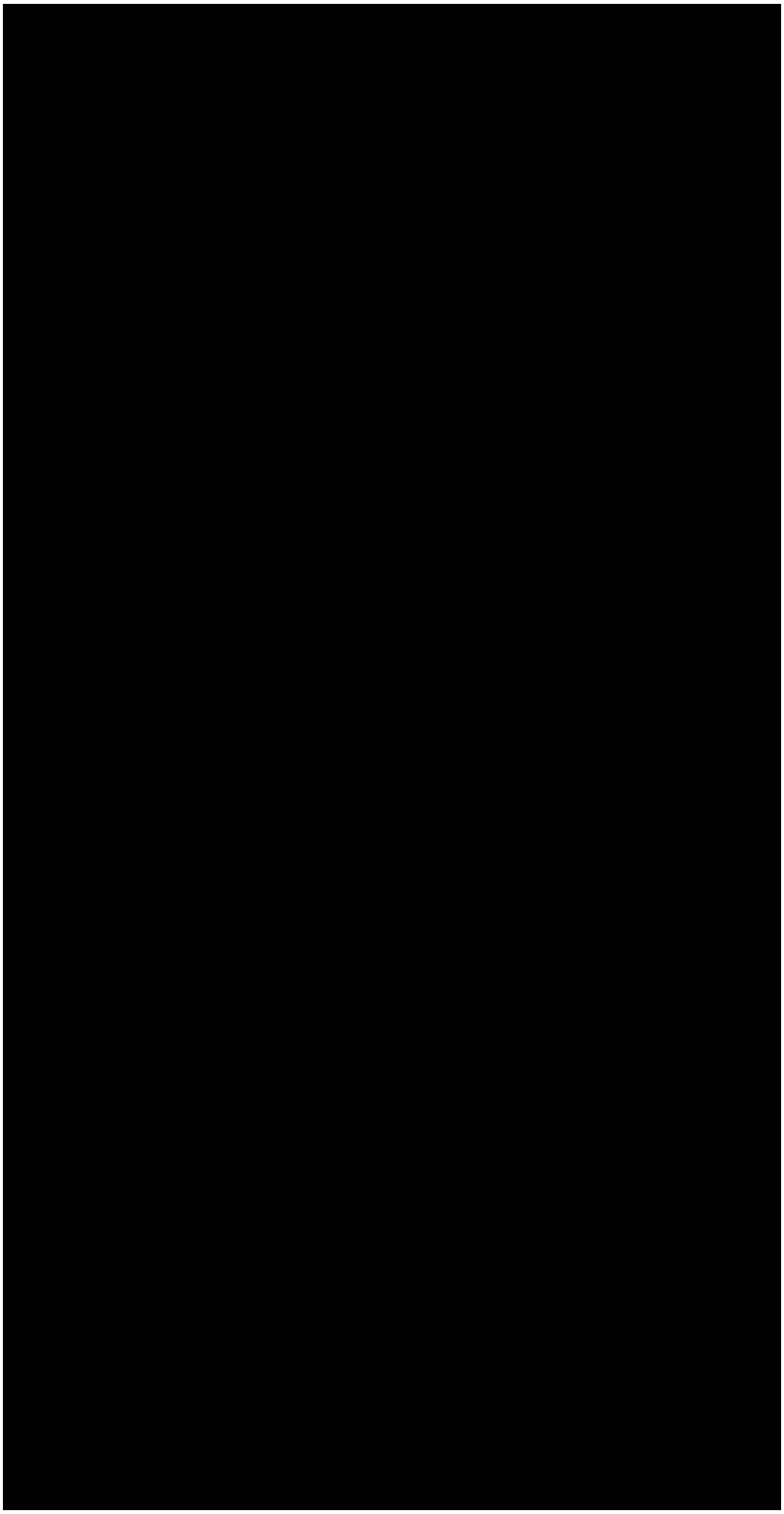

Figure 1. Mortality in the first week of life. (a) rural Indian sample, 2002-03 (ICMR Young Infant Study Group, 2008), IMR 71/1000. (b) Egyptian DHS, 2000 (Campbell et al., 2004), IMR c. 44/1000. (c) aggregated data from rural counties with low IMR (97/1000) (Hertfordshire, Wiltshire, Dorsetshire) and three urban areas with very high IMR (218/1000) (Preston, Leicester, Blackburn), in 1889-91 (Registrar-General of England and Wales, 1892: xii). Note the different measurements of mortality used in each case.

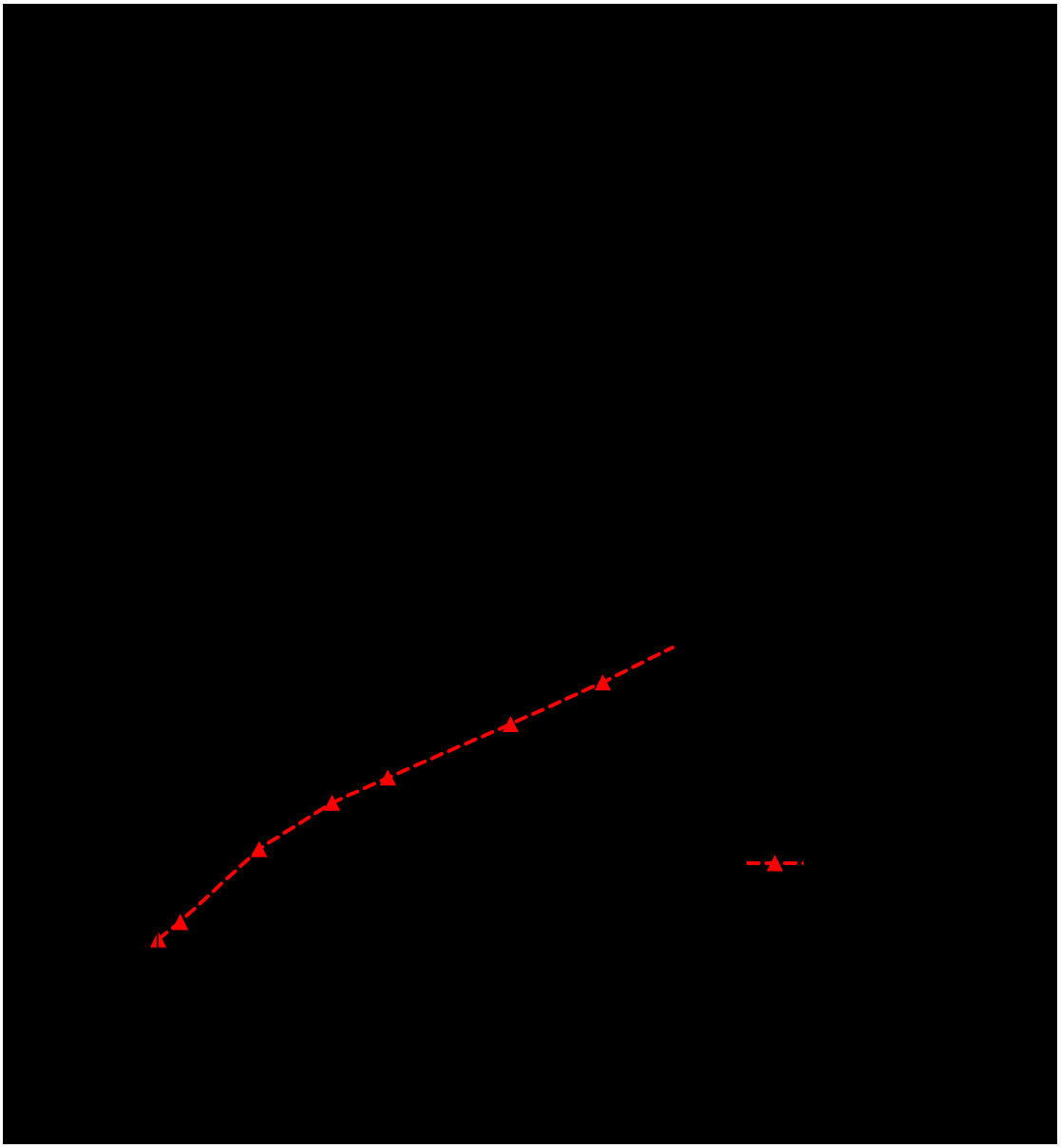

Figure 2. Cumulative percentage of deaths by age in the first year of life, plotted on a log x-axis (Bourgeois-Pichat transformation). Cambridge Group data derive from 26 reconstituted English parishes (Wrigley et al., 1997).

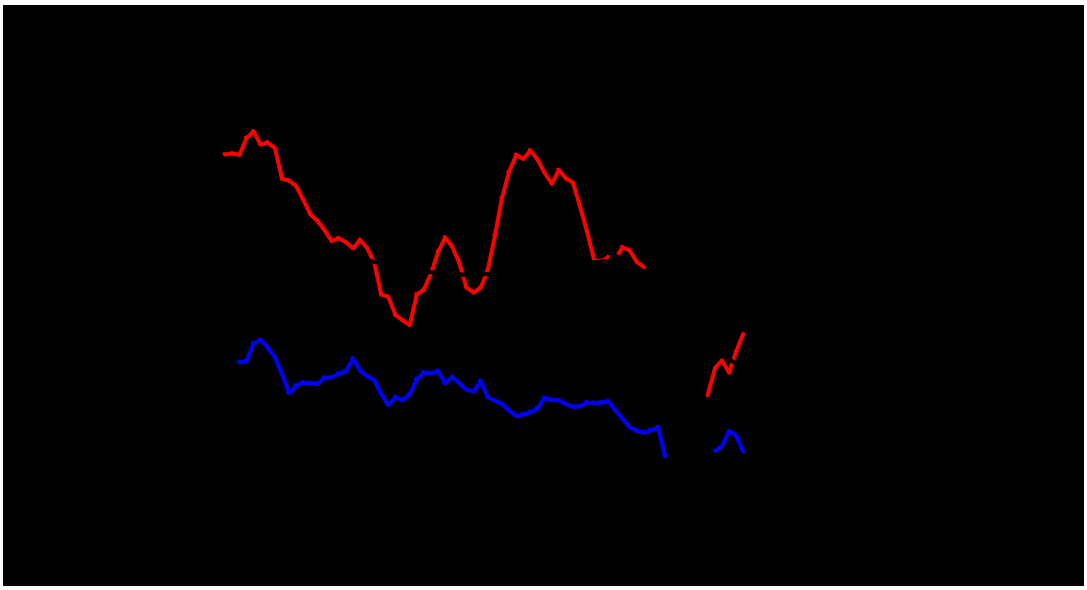

Figure 3. Stillbirth and early neonatal mortality rates for St. Martin-in-the-Fields, and early neonatal rates for 26 reconstituted English parishes (‘Cambridge Group’: Wrigley et al., 1997). The rates for St. Martin’s are five year moving means, and those for reconstituted parishes decadal averages, plotted at the midpoint of each period.

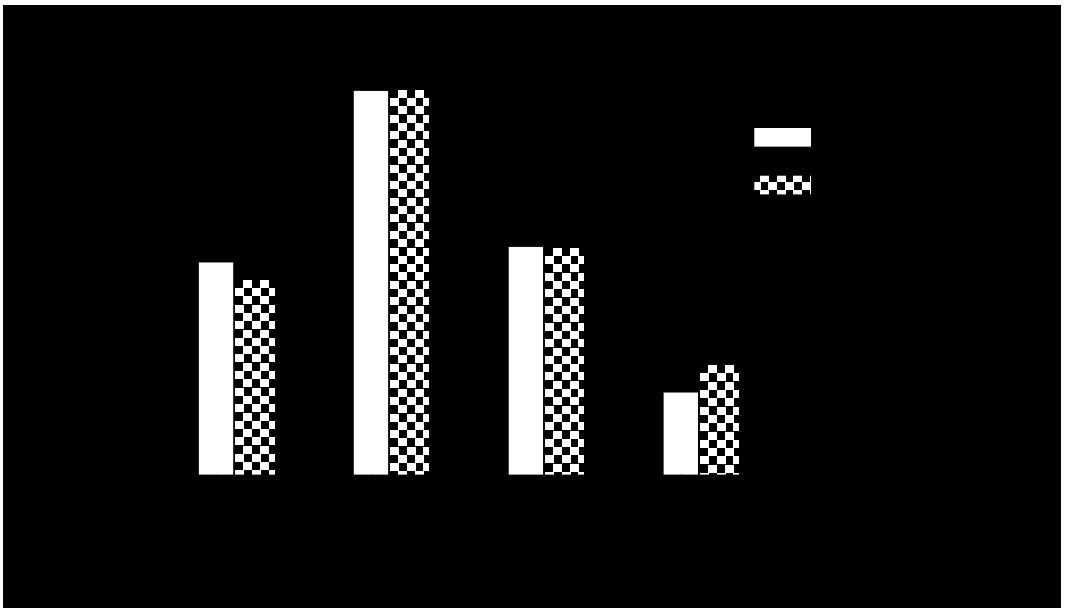

Figure 4. The percentage distribution of burial fees for each age group.

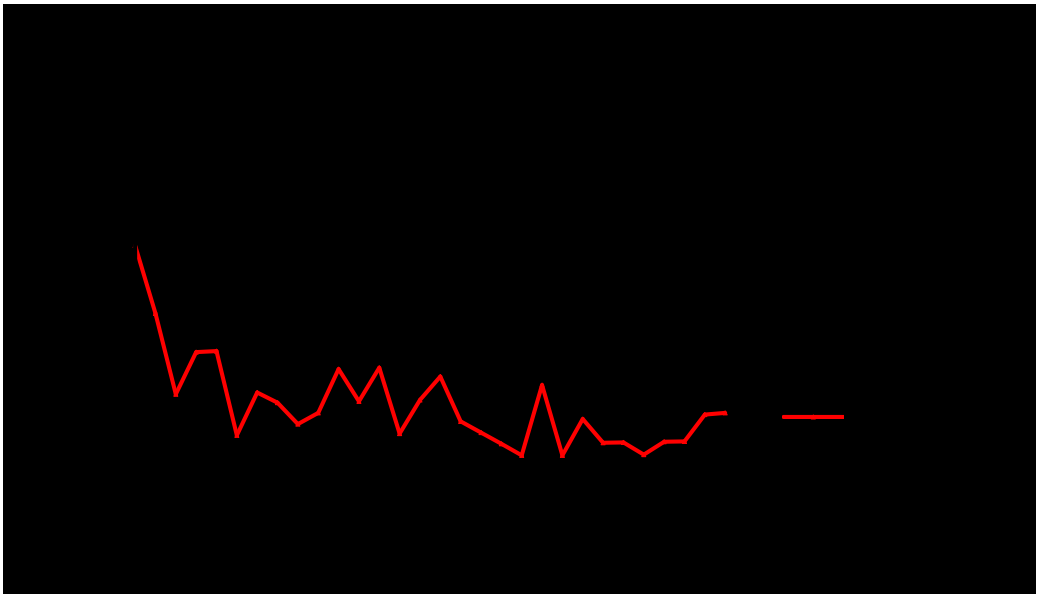

Figure 5. Risk of dying by age (in days) for infants born in the workhouse. N = 1393 births (1737-73), N = 1510 births (1783-1823).

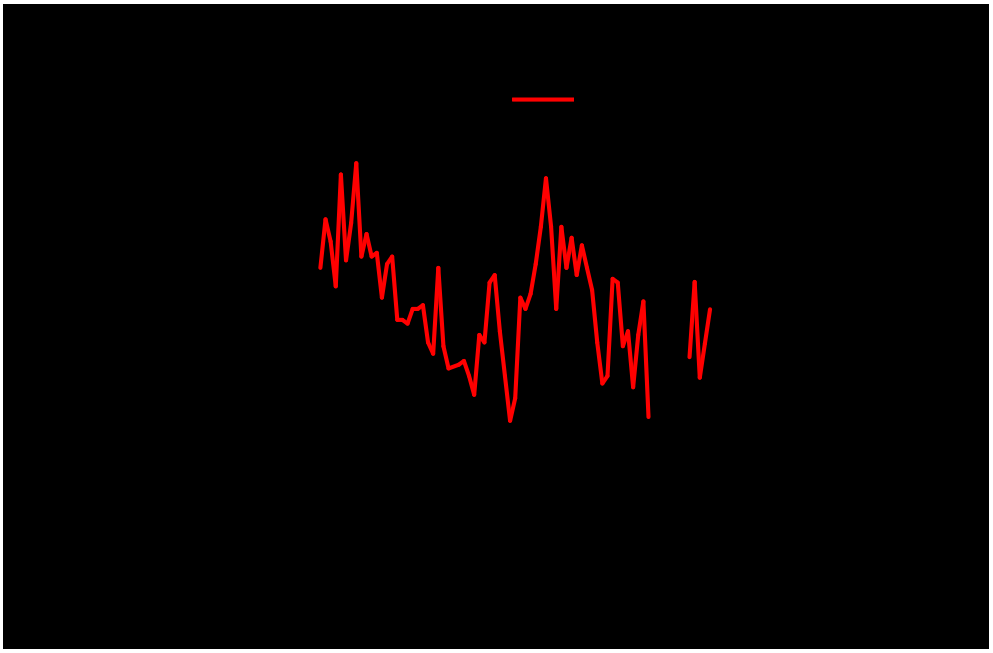

Figure 6. Annual stillbirth rates in St. Martin-in-the-Fields and in the London Bills (Marshall, 1832), calculated using recorded stillborn and abortive burials, and baptisms.

Table 1. WHO definitions (WHO, 2006)

rate	Age at death	Measurement
Stillbirth	From 22 weeks gestation to birth	Deaths per thousand births (including stillborn)
Early neonatal	0-6 days from live birth	Deaths/1000 live births
Neonatal	0-27 days from live birth	Deaths/1000 live births
perinatal	22 weeks gestation to 6 days after live birth	Deaths per thousand births (including stillborn)

Table 2. Percentage of burials by cost category, St. Martin-in-the-Fields 1750-1824[9]

Cost (pence)	Neonatal (days 0-30)[10]	Stillborn	Abortive
0	24%	33%	8
1-49	2%	4%	86
50-99	37%	59%	3
100-1428	38%	4%	3

Table 3. Probability of being baptised early, according to length of life, in 1760.[11]

P of being baptised by day	Died within one month	Died within 2-5 months
7	0.021	0.063
10	0.053	0.85
N (burials)	170	153

[9] There was surprisingly little change in the absolute values of burial fees over the period, for a given type of burial.

[10] Deaths aged 0-30 days were included in the neonatal period, to account for age heaping of deaths on ages 'four weeks' and 'a month', although some of these deaths would be post-neonatal.

[11] Probability of being baptized by a given day after birth was calculated from the daily rates of baptism. For infants who died in the first month, the probability of being baptized by day 7 was 1- [(1 - number baptized on day 1/total who died in first month)*…(1 - number baptized on day 7/those still alive on day 7, who died in first month)]. Only burials of infants who died in the first six months of life were analysed, to reduce effects of migration on apparent baptism rates.