Infant mortality by social status in Georgian London: a test of the 'epidemiological integration' model

RJ Davenport[1], JP Boulton[2] & J Black[1]

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Introduction

The demographic transition, the global transition from high fertility and mortality rates and low population growth rates to low mortality and fertility rates with an intervening period of substantial population growth, has its origins in north-western Europe in the late eighteenth century. This is the period when mortality first fell decisively, and together with a rise in fertility initiated sustained population growth in the countries of the North Sea basin. In the case of Sweden mortality decline was sustained virtually uninterrupted from c.1750 throughout the nineteenth and twentieth centuries. In Britain the mortality decline that was initiated in the 2' half of the eighteenth century faltered in the middle decades of the nineteenth century as a consequence of the massive redistribution of the population from rural to urban centres where death rates were higher, and only resumed again after 1870 (Woods,1985; 2000). This paper considers the first stages of the mortality decline in England.

At the aggregate national level the improvement in life expectancy after 1750 was relatively modest, and superficially only represented a return to mortality levels prevailing in the sixteenth and early seventeenth centuries. However this summary measure obscures very large changes in the age structure and temporal patterns of mortality that signalled a major epidemiological transition. The volatility of mortality declined and the incidence of major mortality crises fell dramatically, most notably with the disappearance of plague after the 1660s but progressively if less dramatically throughout the seventeenth and eighteenth centuries (Wrigley & Schofield,1989). In tandem with this reduction in the amplitude of crises was a shift in the age structure of mortality. Adult survival improved progressively from the late seventeenth century as child and infant mortality worsened (Wrigley et al., 1997).

The most plausible explanation for these changes is the increasing economic integration of the English population over the early modern period (Wrigley et al. 1997; Smith & Oeppen, 2006). According to this hypothesis improvements in transport links and trade reduced the frequency and severity of subsistence crises but also promoted an epidemiological integration of the population that favoured the more frequent circulation of infectious diseases. Thus diseases that had once appeared occasionally and infected people of all ages gradually increased in frequency as contacts between communities increased. In the case of diseases which conferred long-lasting immunity then their increased circulation would have resulted in more frequent but individually less lethal epidemics as an increasing proportion of the population became immune through prior exposure. This would produce

[1] Cambridge Group for the History of Population and Social Structure, Dept of Geography, University of Cambridge
[2] School of History, Classics and Archaeology, University of Newcastle
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the pattern observed in the English population in the period 1600-1750 of a reduction in the severity of mortality crises against a background of rising average mortality rates as the frequency of epidemics increased. Adult mortality fell, consistent with a rise in immunity amongst adults, and childhood mortality rose (as diseases such as measles and smallpox became childhood diseases). While infant mortality actually fell after 1750 this improvement too can be accommodated within a scenario of rising infectious diseases rates in childhood. Improvements in infant mortality in the national population were confined mainly to the first month of life when mortality is dominated by 'endogenous' causes arising from factors operating in utero or during delivery and when infants are protected to some extent from infection by maternal antibodies (the extent depending partly on maternal immunity). The importance of maternal health and immune status to infant survival is highest in the first month and wanes with infant age. The epidemiological integration hypothesis can therefore accommodate falls in infant mortality on the assumption that improving maternal health outweighed the influence of the exogenous disease environment at the youngest ages (Smith & Oeppen, 2006).

The third change that occurred in the second half of the eighteenth century was a dramatic fall in mortality in urban areas. The deterioration in national life expectancy that occurred in the late seventeenth century was amplified in urban areas, and in the period c.1650-1750 most large towns and cities appear to have functioned as demographic sinks, with such high death rates as to require a constant inflow of migrants to sustain their populations (Galley, 1995; Galley & Shelton, 2001). However after c.1770 there is abundant but unreliable evidence of a surge in baptisms relative to burials and the emergence of a new pattern of natural increase in towns. Estimates of infant mortality in London from the London Bills of Mortality and from family reconstitution of several London Quaker meetings (discussed further below) suggest that mortality in the first year of life fell from around 350-400 deaths per thousand births in the early eighteenth century to the national average of c.160/1000 by the 1840s (Laxton & Williams 1989; Landers, 1993). Jan de Vries has argued that before the late eighteenth century no national population could sustain levels of urbanisation above a theoretical threshold of c. 40% without suffering population decline (de Vries, 1984). This new ability of towns to grow their own populations was essential to the rapid urbanisation that accompanied industrialisation in the nineteenth century.

The worsening and subsequent recovery of mortality over the seventeenth and eighteenth centuries in the national population was writ large in the urban sector and it is possible that much of the change registered at the national level was driven by changes in urban settlements. This would seem to present a serious challenge to the dominant explanatory hypothesis. While increasing economic and epidemiological integration would be predicted to have resulted in heightened mortality in urban populations as epidemics became more frequent and fell increasingly upon the youngest ages, as was observed in the period 1650-1750, it is harder to see how a further intensification of this process should have resulted in significant improvement in mortality rates after 1750, especially on the scale registered in urban populations. Landers' work on London Quakers indicates that mortality fell not only amongst neonates but also amongst older infants and children, the age groups upon which most endemic infectious diseases should have fallen most heavily. Landers' is the only evidence we have of age-specific mortality rates in London but it is clear from the scale of the improvements that mortality decline cannot have been confined to neonates in the wider London population but must also have occurred in early childhood (in contrast to the national picture and in apparent contradiction to the predictions of the epidemiological integration hypothesis).[4]

This paper attempts to investigate the implications of urban mortality trends for our understanding of the drivers of the first stage of the 'Mortality Revolution' (Easterlin, 1996) using new evidence for London in the period 1752-1812. Using a parochial population that was broadly representative of the London population as a whole we can test to what extent mortality rates derived from London Quakers reflect mortality levels and trends in the metropolitan population as a whole. London Quakers were a relatively affluent group and may have differed from the majority of the population in child care practices including for example breastfeeding regimes, hygiene and smallpox inoculation (Davenport et al. 2011). The next section outlines the difficulties in conducting a study of this type.

Family reconstitution in urban populations

While changes in mortality levels in the national population are fairly well characterised (although little is known of changes in the causes of death which accompanied these shifts), our understanding of the dramatic changes that occurred in urban populations is much more limited. Urban populations are much less amenable to the techniques of family reconstitution which are the sole source of our detailed understanding of age-specific demographic rates in historical English populations. In the absence of population registers our only knowledge of historical population size and structure of English communities must be estimated indirectly from the records of baptisms, burials and marriages. Not only are these imperfect measures of the incidence of births, deaths and family formation but in most cases the records contained no information on age, making it impossible to estimate age structure or age-specific mortality rates directly. Family reconstitution provides a method for reconstructing the population structure of a proportion of a population using well-defined rules to establish which individuals were present in the population ('in observation') and at risk of marriage, reproduction and death, from which age-specific sex-specific rates of these events can be calculated. Families are normally reconstituted from the marriage of two adults and the subsequent baptisms and burials of their children. Ideally the parents' dates of baptism and burial are also known, giving a full reproductive history from which age-specific fertility and mortality rates can be calculated. A key requirement is that individuals identified in one set of records (for example baptism or marriage) can be linked with some confidence to the same name in other records (such as burial records). Obviously this technique works best in relatively small and well-defined communities with a reasonable diversity of names. The twenty-six parish sample used to reconstruct demographic rates for the English population comprised mainly rural villages and lacked substantial towns and metropolitan parishes (Wrigley et al., 1997).

In the case of urban populations high migration rates and the multiplicity of parishes usually comprising a town mean that very few individuals were baptised, married and spent their adult lives in the same parish (Newton, 2011a). Most London residents were not born in London and so we cannot establish their age at marriage or reproduction in the absence of this information in marriage and baptism records. More problematically the large number of parishes in London means that even 'micro-moves' between streets could take a family out

[4] Claims that many infectious diseases are more benign at younger ages (e.g. Kunitz, 1983) will be dealt with elsewhere. They are not borne out by national trends in age-specific mortality in any case.

of observation if they crossed a parish boundary and began to register their events in a neighbouring parish. Therefore urban reconstitutions can usually only capture a fragment of a family's reproductive history, and can only rarely provide information on adult mortality rates. The very large size of the population also means that the probability that two records with the same name refer to the same individual is low in the absence of other corroborating evidence such as age at death or street address. Moreover there is evidence of a market for burials and even baptisms in early modern London that meant that families apparently living and baptising children in a parish may have been burying their members at cheaper sites elsewhere (Schwarz & Boulton, 2010).

The problems of family reconstitution are exacerbated in eighteenth and early nineteenth century English populations by a growing tendency to delay baptism, by the spread of non-conformism, and by the rising fashion for private baptism particularly in urban areas. All these practices could lead to substantial under-registration of births (Wrigley, 1977; Berry & Schofield, 1971). Since the most dangerous days of all are the first few days of extra-uterine life, any delay in baptism could result in infants dying unbaptised unless steps were taken to baptised high risk infants rapidly. The absence of a baptism record in these cases would lead to an underestimation of births, and possibly also deaths if interments of unbaptised infants were not recorded in the burial registers. Private or home baptisms present a potentially larger problem. Anglican rules regarding private baptism in this period stipulated that infants privately baptised should be brought at some later point to be publicly received into the church and registered (Boulton & Davenport, 2013). Private baptism exposed the infant to the risk of death before baptismal registration, but may also have led to more widespread under-recording of baptism where the parents never brought the privately baptised infant for registration. In addition to these problems the growth of non-conformism meant that many vital events were never registered in Anglican records. Where families registered all events outside the Anglican church then these families could be ignored on the (rather arbitrary) assumption that their demographic rates were similar to the rest of the population. A problem would arise however if families chose to register baptisms with the Anglican church but to bury elsewhere. In practice the latter problem applies more generally to urban populations wherever there was a market for burials between parishes.

The additional difficulties of family reconstitution in the late eighteenth century have meant that urban reconstitutions have been confined mainly to the period before 1750 (Finlay, 1981: Galley, 1998; Newton, 2011b). The outstanding exception is John Landers' work on London Quakers. Quakers recorded births and deaths rather than baptisms and burials and formed a tight-knit community in which registration of vital events was important to membership. In addition the London Quakers recorded age at death and cause of death which provided both greater confidence in linking individuals and some insight into the changing disease environment. Thus Landers' study avoided many of the problems besetting family reconstitution especially in eighteenth century cities and is our sole source of age-specific mortality rates for London in the period 1750-1837.

Urban reconstitutions from the period before 1750 have established that mortality rose in urban areas over the seventeenth century despite the disappearance of plague (although it is very likely that adult mortality improved as a consequence) (Finlay, 1981: Galley, 1998; Newton, 2011b). Amongst London Quakers infant and childhood mortality rose in the late seventeenth and early eighteenth centuries before falling substantially after 1750 (Landers, 1993). Infant mortality rates peaked at around 340 deaths per 1000 births in the period 1700-

49 but had fallen to 151/1000 by 1825-49 (Landers, 1993: 136). Mortality fell substantially in both the neonatal (the first month of life) and post-neonatal periods (months 2-12) amongst infants, and also halved at ages 1-9 years. Most of the improvement at ages 1-9 was due to a reduction in smallpox mortality after 1750. However improvements in infancy were harder to explain. Birth intervals were short before 1750 and there was a pronounced summer peak of neonatal mortality, features consistent with very brief or no maternal breastfeeding and with hand-feeding of neonates (since food is much more liable to contamination by insect vectors and rapid pathogen growth in summer months). There was a pronounced lengthening of birth intervals after 1750 that coincided with an improvement in neonatal mortality, however the summer peak in neonatal mortality remained, causing Landers to suggest that maternal breastfeeding became more widespread and or more prolonged after 1750 but also that neonatal mortality became concentrated amongst a minority of families where maternal breastfeeding was of very short duration or not practiced. Amongst older infants (aged 1-11 months) smallpox accounted for some of the fall in mortality but most of the improvement at this age where infectious disease predominated remained unaccounted for.

St. Martin-in-the-Fields

To investigate improvements in urban mortality in London outside the Quaker population we exploited the exceptionally rich records of the large London parish of St. Martin in the Fields. The use of burial and baptism fee books provided information not usually found in parish registers (including ages at burial and baptism and street address) that made nominal linkage of individuals much more secure than is usually possible. The richness of detail in the records also made it possible to characterise and to correct for some of the burial and baptism practices that have bedevilled the historical demography of late eighteenth century England (Schwarz & Boulton 2010; Boulton & Davenport, 2013). The records of fees paid for baptism also made it possible to study demographic processes within different social status groups which proved key to understanding the changes occurring within the sample as a whole.

London was the largest city in eighteenth century Europe with a population of around 675,000 in 1750 (Wrigley, 1967), and St. Martin in the Fields had a population of around 25,000 throughout the period 1750-1810, making it larger than all but the greatest towns in England outside London. The parish is located in Westminster near the seat of government and formed part of the westward expansion of fashionable housing in the late seventeenth and eighteenth centuries. Although the parish was home to a number of elite families its physical size and population meant that it provided most of the functions of a town, and its occupational structure in the mid-eighteenth century was typical of London as a whole (Table). The adult population had an excess of adult females reflecting the employment of large numbers of female domestic servants, and the parish workhouse was the third largest in London in 1801. In this period the residential segregation of rich and poor occurred at the level of the street, with the richer families living on the broader streets and poorer residents living mainly in smaller streets and in courts behind the main streets. Both rich and poor lived right by the river, despite the insalubrity of the Thames in this period (see http://research.ncl.ac.uk/pauperlives/).

St. Martin in the Fields has exceptionally rich records of both burial and baptism in the form of fee books that recorded payments for services. The burial entries record age at death, in days, weeks and months for infants, cause of death (including 'abortive' and 'stillborn'), fee paid for burial, street address, and whether the burial was exported to another parish for burial. The baptism fee books record the date of birth as well as baptism, a feature essential to calculating infant age given the often lengthy delay between birth and baptism. They also record the fee paid for baptism. In the period 1752-94 the fee value varied widely (from free pauper baptism to over £11) and could be used as a measure of social status (see below). After 1794 the fee structure collapsed to a two-tier pauper/non-pauper charge (free or 18 pence). Street address was also recorded in both burial and baptism records, facilitating linkages between records in some cases.

The very richness of the records of St. Martins also makes abundantly clear the problems associated with using these data to calculate mortality rates. We know from address and fee information that around 20% of deaths recorded in the burial fee books were exported out of the parish for burial and about ten percent were imported from surrounding parishes, indicating a lively market for burials in London. Exported burials were supposed to be issued a certificate (for a fee) by the parish of residence and although exported burials were not recorded in the burial register they were usually included in the sextons' burial books. To test the comprehensiveness of recording of burial exports we searched the burial registers of the three adjacent parishes where the registers recorded address (St. Giles in the Fields, Covent Garden and St. Anne Soho) for burials described as from St. Martin's. We found that St. Ann Soho had acted as a kind of clandestine burial ground for some of our period (Schwarz & Boulton, 2010) so that only around sixty percent of burials identified as from St. Martin's could be linked to a recorded export in the St. Martin's burial books. The percentage linked was much higher for Covent Garden and St. Giles (although the latter included very few burials from St. Martin's in any case). This evidence suggested that as many as eight percent of burials of residents may have gone unrecorded in the St. Martin's burial books as a consequence of unregistered export in certain periods.[5]

As expected the baptism records indicated a substantial delay between birth and baptism that widened over the late eighteenth century (Boulton & Davenport, 2013). Consistent with this delay the burial records recorded suspiciously few early neonatal burials, and almost no 'chrisom' burials (referring in this period to burials of unbaptised infants). What were abundant however were stillborn burials of infants with no forename, which appeared only in the sextons' books and not the parish burial registers. These accounted for fifteen percent of all burials aged under one year, and their superabundance relative to early neonatal burials indicated that parents were not failing to bury newborn infants, but that many neonatal deaths were recorded as stillborn. The motive may have been to avoid the stigma of an unbaptised death, as there was no financial advantage to choosing stillborn over live-born 'chrisom' burial (Davenport, unpubl.). In addition to 'stillborn' burials five percent of burials aged under one year were described as 'abortive'. We think that the latter were genuine stillborns, but that probably most of those described as stillborn were in fact live-born.

Apart from the under-recording of births caused by deaths occurring before baptism, births were under-recorded as a consequence of rising rates of non-conformism, and the practice of private baptism. We cannot assess the extent of non-conformism in St. Martin's except to note that there were few non-conformist chapels *in* the parish, and very few burials at the

[5] Burial records from the Dissenters' burial ground at Bunhill Fields were also searched but contained very few burials from St. Martin's.

non-conformist cemetery at Bunhill Fields in London were from St. Martin's. A more serious problem was the practice of private baptism. In addition to unbaptised infants buried as stillborn there were large numbers of burials of baptised infants (that is with a forename) who could not be linked to a baptism. While some degree of failure to link infant burials to baptisms was to be expected as a consequence of residential moves between the two events and to nonconformity the age pattern of linkage also suggested that many infants were being baptised and dying before their baptisms were formally registered. Such a pattern could be explained if private baptism were common (Boulton & Davenport, 2013).

The practice of private baptism could be investigated in some detail in St. Martin's. The baptismal fee books often recorded baptisms as 'home christening' and surviving fee schedules indicated the standard charges for public and private baptisms, making it possible to identify most private baptisms. Public baptisms were charged one shilling and sixpence (18 pence) whereas standard private baptisms were charged three shillings and sixpence (42 pence) or later five shillings (60 pence) (before 1795 when differential charges for private baptisms were abolished). Private or home baptisms accounted for c.30% of baptisms recorded in St Martin's. Church rubric of the period stated that home baptisms should be registered when the child was brought to church, and the extent of under-registration of baptisms associated with the rise of private baptisms is unknown. In St. Martin's the higher fees associated with registration of home baptism and the venality of some members of the local clergy assured a high but demonstrably incomplete level of registration. We also found evidence that some parents sought rapid baptism where the infant was in danger. Such baptisms were marked 'P' and occurred with a much shorter lag after birth than the average for other baptisms. These baptisms were associated with very high mortality rates. Such 'emergency' private baptisms were charged a range of fees (including free baptism) consistent with their presumably wide social distribution, whereas other private baptisms were for reasons of fashion or privacy and were associated with higher social status (see below). Some ten percent of baptisms were charged fees in excess of the standard private baptism fee but we have no information on what the extra charge entailed. There was no difference in the birth-baptism lag between public and private baptisms, but we cannot establish from the baptism records whether it was the private baptism itself that was being recorded or some later act of registration. There was a pronounced reduction in the proportion of baptisms that were private after 1770 and again after 1785 (Boulton & Davenport, 2013), but we cannot establish whether these changes represent increases in the under-recording of private baptisms, or a fall in the actual incidence of private baptism in the parish.

Family reconstitution in St. Martin in the Fields

To reduce problems associated with under- recording of births and under- and possibly over-recording of deaths we used a modified family reconstitution methodology (Newton, 2011a). The method involved nominal linkage of over 170,000 records from the baptism, burial and marriage records of the parish as well as marriages of residents from St. Martin in the Fields in the Fleet Prison (1740-54) and burials of St. Martin's residents in the St. Giles, Soho, Covent Garden and Bunhill burial registers. Nominal linkage is complicated in historical sources by the wide variety of spelling variants deployed even in the same source. As a first step forenames and surnames were partially standardised by assigning phonetic codes (Newton, 2011a). These codes were then grouped into 'families' of overlapping phonetically related names by hand and these groups were used for computerised matching of entries in the original sources. Each match was then checked by hand for plausibility. Families were initially reconstructed by linking baptisms with the same parental names and a gap of less than ten years between two successive baptisms.[6] Where the interval between two baptisms exceeded ten years then the births were considered to belong to separate families.[7] Where there appeared to be two couples of the same name baptising in the parish in the same period then these families were either dropped from the reconstruction or two separate families were constructed on the basis of distinct street addresses. Families had to baptise at least two children in the parish in order to be included. 24,521 baptisms (54% of the total) were incorporated into reconstitution families.

Burials aged five or under at death were linked to baptisms on the basis of matching forename and surname and age at burial. The outstanding limitation of the burial records of St. Martin's was the absence of information on the parents of dead children, which meant that nominal linkage between burial and other records was restricted to the name of the dead person and therefore robust linkage relied on additional information such as age and street address. The date of birth was given in the baptism record allowing comparison of predicted age at the date of burial with the age given in the burial records (making some allowance for approximations in recorded age at burial and for the average three day delay between death and burial). However age at burial was not recorded for exported burials before 1767 and was also absent in St. Martin's burials recorded in adjacent parishes but not in the St. Martin's sextons' books. It was however possible to identify burials as those of children, because all burials were marked as child ('C'), adult ('M' or 'W') or stillborn ('S') burial. In these cases child burials were linked to reconstitution families where a baptism of the same name existed and where the street address if given matched one or more baptisms in the family around the date of death. Age at death was then calculated from the dates of birth and burial. Matching of burials to baptisms was performed using the full baptism dataset to avoid biasing linkages towards reconstitution families.

In addition to child burials which could be linked to a baptism there were large numbers of burials of baptised infants that could not be linked to any baptism. There were also numerous stillborn infants who were not baptised but were undoubtedly live-born in many cases. Since we suspected substantial under-registration of private baptisms and mis-registration of live-born infants as stillborn then mortality would be underestimated substantially if some proportion of these burials were not included in the reconstitution. Therefore burials of stillborns and children aged under two not matched to a baptism were matched where possible to baptisms of putative siblings (using the full baptism database) on the basis of surname.[8] Where such burials appeared to belong to a reconstituted family on

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[6] Illegitimate infants were excluded from the reconstitution because of the difficulty of establishing the unique identity of mothers where the name and address were very common. Illegitimate baptisms accounted for c. 3 % of baptisms in the parish and 89% of these occurred in the parish workhouse. Mortality of illegitimate neonates could be studied in some detail using the workhouse admission and discharge records for the parish: see Davenport et al. 2012.

[7] Once dummy births were included (see below) then the maximum birth interval allowed for inclusion in analysis was reduced to six years to reduce the probability of both misidentification of families and under-registration of baptisms.

[8] Burials aged 0-5 years and unknown age were linked to their own baptisms where possible but only burials aged 0-2 years and with no baptism match were linked to sibling baptisms and assigned dummy birth dates. This was because the number of burials lacking a baptism that could be linked to a family dropped substantially with age over the first two years of life, with only five percent of links being to burials aged two

the basis of name and street address but could not be linked to a baptism then a 'dummy' birth was created for the dead child based on the age at death, and that birth inserted into the family if an appropriate gap in the baptisms existed. The insertion of burials and dummy births was restricted to burials with exact age because it was considered too tenuous to assign a date of birth and age at death to burials of unknown age in the absence of a baptism record.[9] Stillborn burials were also incorporated into families with the same surname where an appropriate gap existed in the baptism series and where the street address at burial matched the street address of at least one flanking baptism. Stillborn burials were assigned a date of birth three days before the date of death and were given an age of half a day for event history analysis, that is they were assumed to be live-born and to have lived half a day on average. As discussed above stillborn burials probably consisted mainly of live-born early neonates. Stillborn burials represented 15% of infant burials in toto but only 5% of infant burials in the reconstitution sample so their inclusion is likely to compensate only partially for the dearth of neonatal deaths in the sample and could not cause an overestimation of neonatal mortality.

The final step in the reconstitution process was to link families to a marriage using the marriage fee books and marriages registers for the parish and also marriages registered at the Fleet prison for the period before March 25th 1754 (when Hardwicke's marriage Act came into force) and where entries described one or both partners as from St. Martin's. Marriages were linked to reconstitution families on the basis of groom's surname and parental forenames. Only marriages occurring in the six years before the earliest baptism in a family were linked to a family (although the initial linkage exercise relaxed this rule to allow for the possibility of false linkage of baptisms or retrospective legitimation of baptisms). We could only link parents to their marriages in c.23% of families, indicating the high mobility of residents (as well as the market for marriage venues in the capital). At first glance this would suggest that our sample may be missing a high proportion of first births (which carry higher risk). We have no data on age at marriage or at childbirth so we can't estimate to what extent our sample is biased towards low or high parity births, or how many couples may have married elsewhere but settled in St. Martin's before their first birth. The brevity of the period in which most reconstitution families were in observation in the parish is illustrated in Figure 1 showing the distribution of number of births by social status group (the definitions of social status groups are described below). The window of observation in terms of number of births was smaller for poorer families and widest for the wealthiest ten percent of the sample, reflecting both the higher residential mobility of the poor and the shorter average birth intervals among the wealthy (see below).

Social status

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years. This suggested that baptismal registration of survivors was fairly complete by age two, an assumption that was key to the reconstitution process since unbaptised children could only be incorporated into the reconstitution if they died so any substantial permanent under-registration of baptisms (through failure to ever register private baptisms or instance) would have caused a serious under-estimation of the population at risk. This assumption was tested using birth interval analysis – see below. Burials aged 0-5 were linked to their own baptisms in order to establish the fate of as many infants as possible for birth interval analyses.

[9] The usual practice in the case of reconstitutions of parishes with very scrupulous record-keeping and where no age at death or baptism was recorded is to assign a child burial of unknown age a dummy baptism with the same date as the date of burial. This was not possible in St. Martin in the Fields because the potentially long delays in baptism and the very high death rates throughout childhood made it dangerous to assume that unbaptised burials were confined to the very young.

The fees paid for baptism was used as a measure of the social status of reconstitution families. Baptism was expensive and baptism fees showed substantial gradation in the period before 1795 (ranging from free to 2,652 pence or £11 and 1s). The daily wage of a building labourer in London for most of the eighteenth century was 24 pence a day (when employed), making even the standard fee of 18 pence for public baptism a not inconsiderable expenditure. Reconstitution families were assigned to one of four social status categories that reflected the structure of baptism fees and provided adequate differentiation without creating groups with too few members for analysis. In many cases families paid different fees for successive baptisms and so the method adopted was to assign each family the social status category of the highest baptism fee paid except in the case of those ever described as poor in a baptism entry, who were assigned pauper status. The rationale for this method was that families who could afford the higher fees at least on some occasions were probably wealthier than those who never paid a higher fee. However those described as 'Poor' by parish authorities were considered paupers although on some occasions they may have been able to pay the standard fee for public baptism. The four groups so constructed were (0) paupers (families who never paid for baptism or who were described as poor at least once); (1) standard baptisms (families that never paid more than the standard baptism fee of 18 pence and didn't meet the pauper criteria); (2) private baptisms (families that paid the standard private fee of 42 or 60 pence for at least one baptism); and (3) the wealthy (families that paid in excess of the standard baptism fee on at least one occasion). There were a small number of families who were initially assigned pauper status but were clearly very wealthy, a situation which arose because parish clerks were instructed not to approach 'those of fashion' for fees lest they give offence (Boulton & Davenport, 2013). These elite non-feepayers could only be detected easily where the high social status of one or both parents was given in the baptism record: in these cases the family was reassigned to the highest social status group.

Reconstituted families contained fewer pauper baptisms than the sample as a whole (a function in part of the exclusion of illegitimate births) but otherwise the distribution of baptism fees resembled the parish as a whole (Table 2). However when families were allocated to social status categories using the method described then the proportions of baptisms in families in the higher status categories increased (because families that paid two different levels of baptism fees were elevated into higher status categories) but the pauper category was also inflated (because families described as 'poor' at one baptism were allocated to the pauper group even if they paid the standard public baptism fee on another occasion). The method had the virtue of distributing most of the large fraction of baptisms with no fee given into known status groups, and created four groups of sufficient size for analysis, with pauper and wealthiest families each comprised about ten percent of the sample. There was a reduction over time in private baptisms in the parish which was reflected in the growth of the 'standard baptism' category at the expense of the 'private baptism' category of families (Boulton & Davenport, 2013). As explained in the next section these two intermediate groups probably overlapped considerably in terms of income and social status. From 1795 the baptism fee structure collapsed to a simple two-tier system and it was only possible to distinguish pauper families (c.4% of the sample) from non-paupers (96%).

A key question is the extent to which baptism fees provided a useful proxy for the actual wealth or social status of the reconstitution families. We used two other sources of information on wealth to assess the utility of baptism fees as social status indicators. The first was the Westminster rate books which listed the estimated rental value of dwellings (the basis of the assessment for poor rates). The only rate book available in machine-readable form for the period 1752-94 was that for 1784 (Westminster Historical Database, UK Data Service SN 3908). We matched male ratepayers in 1784 to fathers named in baptisms in the years 1783-85 using the nominal linkage procedure outlined above and street address.[10] We were only able to link 24% of fathers to an entry in the rate book, and the proportion linked rose with social status as indicated by baptism fee. Only one pauper baptism could be linked to a rate book entry presumably because most families who did not pay for baptisms were too poor to live in properties of sufficient rental value to be rateable. 18% of standard 18 pence baptisms could be linked to a rate book entry compared with 52 and 54 % respectively of private and higher non-standard fee baptisms. Figure 2 indicates that assessed rental values overlapped considerably in the three non-pauper groups but showed a progressive rise with increasing baptism fee. The extent of overlap between particularly the two intermediate social status groups is however exaggerated in Figure 2 because a much smaller proportion of families in group 1 (those paying 18 pence for public baptism) could be linked to a rate book entry at all, suggesting that most families in this category may like paupers have been exempted from the rate.

The second source of information on wealth is the fee paid for burial. While baptism was not cheap burials were considerably more expensive, at 7s 4d (88p) for the cheapest non-pauper fee and with an elaborate schedule of fees according to where and when the burial took place and with what ceremony. As with property rates there was both a clear gradient in fees with social status and considerable overlap in burial fees between social status groups (Table 3).

On the basis of comparison with property rates and with burial fees it therefore appeared that there was considerable overlap between social status groups defined by baptism fees but that the four groups did represent a definite gradient in wealth and status, with the top and bottom ten percent of the sample reasonably well-defined. Titled parents and most of those designated ‘Esquire’ were confined to the highest status group. Although many wealthy families spent only part of the year (the ‘Season’) in London those families who met the criteria for family reconstitution seem to have been mainly permanent residents because birth intervals were short in this group (as discussed below) and there was no greater seasonality of births in this group than in other status categories. Around half of families in the pauper category were designated as ‘poor’ in the baptism fee books, although this category excluded some of the poorest families in the parish because illegitimate births were excluded from the reconstitution exercise. Some overlap between status groups was to be expected given that families were grouped into only four rather crude categories. However it was also likely that the social status of families was not stable over the period they were in observation and that the occurrence of different baptism payments for baptisms within the same family represented changes in the fortunes of the family. We could not test this directly except to look for evidence of gradients over time in the patterns of fees within families that paid more than one level of fee. It was possible that baptism fees might show some progressive rise in value with successive baptisms as parents increased in social status during the life course, or conversely that fees might decline with birth order as the family was

[10] We were limited to linking fathers to male ratepayers because the Westminster Historical Database project only transcribed entries for male ratepayers.

progressively impoverished by dependent children. However no gradient was observed was observed within the sample as a whole or within status groups (data not shown).

Event history analyses

The primary purpose of family reconstitution is to establish the population under observation at any given time and to measure the rate of events occurring to this population. In the case of the St. Martin's reconstitution families entered observation at marriage or at the birth of the first child if this occurred within a month of the baptism (otherwise baptism). It was necessary to use birth date rather than baptism where possible because the high proportion of 'first' births in the sample (for example where a reconstitution family contributed only two baptisms) and the often substantial lag between birth and baptism would otherwise have meant that a high proportion of those who survived the first month were excluded from the population at risk in the first month of life (because they were not yet baptised) while those most at risk (those baptised early or who died before baptism and were assigned a birth date) remained, which would have resulted in a very substantial overestimation of mortality in early infancy. The assumption made in this case was that families baptising within a month of birth had been resident in the parish since the birth in question. This was felt to be justified in the first month after birth on the basis of migration rates estimated from modelling of burial-baptism linkages by age (data not shown) but became less tenable with longer birth-baptism intervals. There was no significant difference in the distributions of birth-baptism lags between private and public baptisms or by social status so this procedure should not have biased estimates of mortality. Where a burial with only a dummy birth was the first event in a family then this was excluded. Families exited observation at the date of last baptism and the last child was excluded from analysis.

Mortality rates were calculated using product-limit life tables, a technique that take into account the population at risk at daily intervals and recalculates the population at risk every time an individual dies or otherwise exits observation. Mortality rates were expressed as the probability of dying in the age interval per thousand at risk. Mortality rates were calculated only for the first two years of life. Although burials aged under five were linked to reconstitution families where possible in order to establish the fate of infants for birth interval analyses burials aged more than two years that could not be linked to a baptism were not assigned dummy births and this may have produced an underestimation of mortality at these ages (see footnote 8).

The next section describes the first results of event history analysis of the reconstitution sample and evaluates the completeness of the sample.

Under-registration of baptisms and burials

The evidence of substantial levels of baptismal delay, private baptism and export of burials in the parish suggested that there may have been significant under-counting of births, baptisms and burials in the parish. Reconstitution families were drawn from those registering at least two baptisms in the parish and who comprised a more stable group than the population as a whole. Nevertheless some under-counting of events amongst reconstitution families was expected.

Table 4 shows mortality rates for neonatal, post-neonatal and one year age groups in the reconstitution population for three time periods. When we compare these with estimates for the national population (the 26 parish reconstitution sample of Wrigley et al., 1997) and for London Quakers (Landers, 1993), the estimates for St. Martin's appear to be consistent with respect to time trends, but too low in *levels* of mortality. In particular neonatal mortality in St. Martin's was lower than either the Quakers or the national sample in all periods. This was implausible at least for the period before 1800 because even within the 26 parish sample neonatal mortality was higher than average in market towns (as well as amongst London Quakers) suggesting a significant urban penalty in this age range (Wrigley et al., 1997: 270-1). There was substantial geographical convergence to low neonatal mortality over the period 1750-1850, but stark differences appear to have persisted before 1800 and should have been evident in the St. Martin's sample (Wrigley et al., 1997: 232,276). Post-neonatal mortality, which was dominated by infectious diseases, was reassuringly higher in St. Martin's than in the mainly rural national sample at least before c.1800, but was nevertheless rather low compared with London Quakers. There was therefore reason to suspect that neonatal burials and possibly post-neonatal burials were under-counted in the St. Martin's reconstitution. This was further tested using biometric and birth interval analyses.

The classic test for under-registration of burials is the Bourgeois-Pichat or biometric test. Bourgeois-Pichat argued that infant mortality displayed a consistent age pattern regardless of the actual level of mortality, such that if plotted on an appropriate log scale the cumulative rate of mortality over the first year approximated a linear function (Bourgois-Pichat, 1951). The slope of the fitted line represented the accumulation of deaths due to mainly infectious diseases. Where the fitted line crossed the x-axis, at birth, this value gave a measure of the endogenous component of mortality, those deaths attributable to causes arising *in utero*, during the birth process or deriving from genetic factors, and includes major causes such as prematurity and low birth weight as well as infections acquired during birth such as neonatal tetanus and early onset sepsis. The technique could also be used to detect under-registration of early infant deaths in the case where the constant was too small to be plausible or the linear fit was poor. Subsequent work on historical populations has demonstrated that non-linear fits to cumulative infant mortality are more appropriate than linear fits under certain scenarios where infectious disease mortality was very high especially in the second half of the first year of life as a consequence of early weaning or very high exposure to disease in the context of waning maternally-derived immunity (Woods, 2000; Knodel & Kintner, 1977).

Figure 3 shows biometric plots of infant mortality for all reconstitution families for three periods. For all periods non-linear equations (second-order polynomials) provided a better fit than linear equations, consistent with the extreme disease environment of London in this period. Endogenous mortality calculated in this way was comparable to rates amongst London Quakers and the national sample (Table 4). However endogenous mortality was measured in this way was too close to total neonatal mortality rates to be plausible (suggesting as it did that almost all mortality in the first month of life was concentrated near birth). This implied that the non-linear shape of cumulative mortality in each period was in part a consequence of the under-registration of burials, and that this under-registration was not confined to the early neonatal period.

Another means to test whether especially early infant burials were omitted from reconstitution families is birth interval analysis, a technique developed by Louis Henri and exploited by Wrigley et al. (1997: 102-5). Birth intervals, the interval between one birth and the next, reflect the play of factors dictating fertility in a population that is not practicing deliberate birth limitation. In the English population in this period the main determinant of the interval between one birth and the next was the duration and intensity of maternal breastfeeding (Wrigley et al. 1997; Wilson, 1986). If sufficiently frequent and intense breastfeeding suppresses the recovery of fecundity after birth, and so delays conception of the next child. In the English population in the eighteenth century relatively long maternal breastfeeding was the norm. Average birth intervals (where the child survived) were around 30 months, consistent with extended breast-feeding of perhaps fourteen to eighteen months' duration (Wrigley et al. 1997; Wilson, 1986). However if the infant died before weaning then this caused a cessation of breastfeeding and an early resumption of fecundity, resulting in a shorter interval to the next birth than was the case where the first child survived. In reconstitution studies a third category of infants can be identified who cannot be confirmed as having either survived the period of breastfeeding or died early, because they never appear in any subsequent record. It is possible that some of these infants of unknown fate may have died and their burials gone unrecorded. If they died significantly before the average age of weaning then these early undetected deaths would result in a higher proportion of short birth intervals in this group than is the case for infants known to have survived to weaning. In the national sample the distributions of birth intervals following the baptism of infants of fates known and unknown was virtually identical, indicating relatively complete burial registration (Wrigley et al. 1997: 104-5).

We applied the same analytical technique to births in the reconstitution families of St. Martin's. In the case of infants who died early (in the first six months of life) the distribution was as expected. The modal birth interval was twelve months and the distribution was very similar to that of the national sample (Wrigley et al. 1997: 102-4), with only minimal evidence of missing baptisms or births (which should show up as a larger than expected 'tail' of long intervals) (Figure 4).[11] In the case of the 'fate known' category of children surviving infancy, in St. Martin's children could be established as having survived the first year only through tracing their baptism to a later death (since they could not be followed to other events such as marriage). We only linked burials aged 0 - 5 years to reconstitution families so infants of known fate include only those dying before the age of five. For infants known to have survived the first year of life the distribution was very different from that of the national sample with local maxima at 16 and 24 months in the period 1752-74. This suggested that the sample included some mix of breastfeeding practices. The average birth interval was 23.4 months in this period, much shorter than the average in the national sample. This suggested both a lower prevalence and/or shorter duration of maternal breastfeeding in St. Martin's. It also suggested, like the birth intervals amongst infants who died early, that

[11] Using slightly different estimates of fecundity in the early modern English population Wrigley et al. (1997) and Wilson (1986) estimated that the proportion of birth intervals exceeding 60 months should be c.1.8 to 2% of intervals if birth registration were complete. In St. Martin's reconstitution families the proportions of birth intervals exceeding 60 months were 1.4 % (1752-74), 2.4 % (1775-94) and 2.8 % (1795-1812) (including dummy births). These data suggest some degree of omission of births especially after 1775 but the extent of the problem is surprisingly slight given the expectation that some proportion of live-born infants buried as stillborn were excluded and the high rates of private baptism evident in the parish.

omission of births from reconstitution families was not a significant problem (see footnote 11).

If registration of infant burials were fairly complete then the distribution of birth intervals birth intervals where the fate of the first infant is unknown should resemble closely the distribution of intervals following the birth of infants known to have survived infancy. In the case of St. Martin in the Fields the distributions clearly differed, with the distribution of birth intervals in the unknown fate category clearly skewed towards shorter birth intervals (Figure 4). This suggested that breastfeeding was more likely to have been cut short, or never initiated, amongst infants of unknown compared with known fate. The most obvious reason for this phenomenon would be that the former group contained a proportion of unobserved early deaths that hastened conception of the next child. However an alternative explanation was that some proportion of infants in this group were removed alive from the parish early in infancy while their mothers remained in observation. In seventeenth and early eighteenth century London infants of wealthy families were sent in large numbers to rural parishes near London to be wet-nursed usually for some years before returning to their family (if still alive) (Fildes, 1986; 1988; Clarke, 1987). Infants who died at nurse were usually buried in the rural parish and so their burials would go unrecorded in their family's parish of residence. This type of practice poses a problem for reconstitution since the mechanism for establishing whether a child remains in observation (apart from his or her own burial) is the continued presence of the family as evidenced by sequential baptisms in the parish. Newton established by comparing census-type data derived from the imposition of the Marriage Duty Assessment in 1695 with family reconstitution data for several London parishes that infants aged under three years were particularly likely to be excluded from the census, suggesting that they were elsewhere even though their families remained in observation (Newton, 2011b).

These two possibilities regarding the fate of infants in the unknown fate category of birth intervals provide two alternative mechanisms for adjusting mortality rates to take into account the evidence of missing burials.

Adjustment of mortality rates for missing burials

Biometric and birth interval analyses established that some proportion of infant deaths in reconstituted families probably escaped inclusion in the reconstitution. Birth interval analysis also suggested perhaps surprisingly that births (either baptisms or dummy births) were probably relatively complete.

We could calculate the number of missing infants by regressing the distribution of birth intervals amongst infants of unknown fate as a function of the distributions of birth intervals where the first infant died early or late (with the constraint that the co-efficients of the latter two distributions must equal one) (Wrigley et al., 1997).[12] This was done separately for each period to estimate the number of missing infants from the unknown fate category. In each case the population at risk was adjusted by subtracting the missing infants (either at birth or at death depending on the adjustment method) and by adjusting the rate at which children were censored from observation (so that exits were not double-counted).

[12] $Y = a*X + b*Z$ where Y is the distribution of birth intervals in the case where the fate of the first child is unknown, X the distribution in the case where the first child died, Z is the distribution of birth intervals where the first child survived infancy, and $a+b = 1$.

If we assume that missing infants were missing mainly because they were sent to rural parishes for nursing then we can simply exclude this fraction of the births from observation on the grounds that they left observation sometime after baptism. This method assumes that the mortality rates amongst those omitted were similar to those remaining in the sample and so they can be omitted without biasing mortality. The removal of these infants from the sample would inflate mortality by reducing the population at risk but leaving the burial count unchanged.

If however we assume that all missing infants remained in the parish but their deaths went unobserved, then it is necessary to add back all the missing infants as burials. These burials could be missing as a consequence of the high levels of burial export in London and the inadequacy of the mechanism to register these exports in the home parish. We established in the case of St. Ann Soho that a high proportion of burials from St. Martin's were not recorded as paying a fee for export in the St. Martin's sextons' books (although these burials were in fact extracted from the St. Ann's register and included in the reconstitution). Although we searched those parishes surrounding St. Martin's that included parish of death in the burial register we were unable to incorporate burials from parishes where no address information was given. Therefore it is possible that there was a significant export of infant burials that went unrecorded in St. Martin's, although we have no direct evidence of this. In order to incorporate these additional missing burials into the calculation of mortality we distributed a quarter to the mid-point of the neonatal period and the remaining three-quarters to the mid-point of the first year of life. While the neonatal period was the most dangerous, the rationale for this very crude redistribution was that the infants known to be missing had all been baptised (since they had no burial record and therefore could only be included in the reconstitution as a consequence of baptism). Given the distribution of age at baptism most missing infants were baptised late in or after the neonatal period and so a high proportion of their deaths probably fell in the post-neonatal rather than neonatal period.

Table 5 shows mortality rates for children under two in St. Martin's assuming no adjustment, or adjusted for missing infants either by removing them from observation or by assuming they all died in the parish. The levels of mortality are clearly higher in both adjustment scenarios, and highest where all missing infants are assumed to have died. However the time trends are fairly consistent at each age regardless of the adjustment procedure. When we compare the adjusted rates for St. Martin's with rates for London Quakers and the national 26 parish sample then the mortality rates adjusted under the assumption that all missing infants died are strikingly similar to the metropolitan Quaker sample and comparable to the crude estimates of infant mortality from the London Bills, suggesting that this assumption was the most plausible. From this point forward we will consider mainly these highest adjusted rates for St. Martin's, but it is important to remember that time trends in age-specific mortality were fairly uniform under all assumptions.

The timing of mortality declines within the three reconstitution studies showed very interesting parallels. A significant decline in neonatal mortality was evident in all three populations (Table 5). This improvement in the first month of life was the sole source of infant mortality decline in the late eighteenth century in both the national and St. Martin's samples. Amongst London Quakers there were also significant improvements at all ages under ten in the last quarter of the eighteenth century (Landers, 1993: 137). These improvements were associated with a specific reduction in smallpox mortality (although smallpox could not account fully for the fall in mortality in post-neonatal infants). The size of the fall in smallpox mortality amongst London Quakers before the advent of vaccination suggests that Quaker families embraced smallpox inoculation in the late eighteenth century (Landers, 1993; Davenport et al., 2011). In St. Martin's but not the national sample there were also dramatic improvements at ages 30-729 days that paralleled those of London Quakers but which occurred substantially later, in the first decade of the nineteenth century rather than the last quarter of the eighteenth.

In the next section we attempt to account for the timing and scale of improvements in neonatal mortality in St. Martin in the Fields using analyses of mortality and birth intervals by social status. Comparisons of trends in social status groups allowed us to tease apart the heterogeneity of feeding practices evident in Figure 4 and to test hypotheses regarding the drivers of mortality change according to their predicted impact on different status groups. Space precludes a discussion here of post-neonatal mortality and the contribution of smallpox and smallpox prophylaxis to the decline of mortality at ages 1-23 months where infectious diseases predominated.

Infant feeding practices and the causes of improvements in neonatal mortality

Three main types of explanation have been proposed to account for the decline in infant mortality in the period 1750-1820: (1) an increase in the prevalence or duration of breastfeeding (e.g. Fildes, 1980; Landers, 1993: 152; Edvinsson et al., 2008); (2) exogenous changes in pathogen characteristics or climate (Fridlizius, 1984; Perrenoud, 1997); (3) improvements in maternal health, via improved nutrition (e.g. Fogel, 1986; Hart, 1998; Wrigley, 1998; Floud et al., 2011) or a reduction in infections (Wrigley et al., 1997; Smith & Oeppen, 2006; Woods, 2009). Amongst London Quakers neonatal mortality displayed a strong summer peak indicative of minimal breastfeeding, and Landers hypothesised that improvements in neonatal survival may have been driven mainly by an increase in the prevalence and/or duration of breastfeeding. This hypothesis was consistent with a lengthening of birth intervals in the late eighteenth century (Landers, 1990). However the summer peak in neonatal mortality persisted amongst Quaker infants even as mortality rates fell, a conundrum that Landers explained by the possible persistence of hand-feeding in a minority of infants, amongst whom mortality became concentrated (Landers, 1993). Our data do not permit us to test all of these hypotheses. However we can explore the impacts of changes in infant feeding practices using birth interval analyses, and we can test the role of maternal nutrition by comparing changes in neonatal mortality by social status.

Our data allow us to examine Landers' hypothesis in some detail using birth interval analyses, on the assumption that birth intervals largely reflect patterns of maternal breastfeeding in this period. There is considerable qualitative evidence that infant feeding practices varied widely between social status groups in this period with consequences both for infant mortality and for birth intervals and hence fertility. It is well-established that maternal breastfeeding although the norm in most of English society was unusual amongst elite families in the seventeenth and for most of the eighteenth century. For these families wet-nursing was a preferred although not exclusive option and infants were often sent to rural parishes for a period of years. The limited evidence on the social status of London families sending infants out of the city to be wet-nursed indicates that the practice was common to a wide range of social status groups from gentry and professionals to small sole traders (Clark, 1987). Over the course of the late seventeenth and early eighteenth century Fildes and Newton have argued that there was rising preference for wet-nursing within the parental home, and Fildes also claimed that there was increasing experimentation with hand-feeding as an alternative to wet-nursing (Fildes 1986, 1988a; Newton, 2011b). Fildes associated these changes with an increasing concern with the influence of wet-nurses and their milk on the physical and moral characteristics of their charges. She argued that the practice of sending infants out of London for nursing became very rare after c.1750 and suggested this was a consequence of the rising demand for rural wet-nurses created by the London Foundling Hospital and possibly a reaction to the adoption of this elite model for foundling infants. Maternal breastfeeding apparently gained in popularity amongst the elite in the late eighteenth century, and together with changes in attitudes towards the importance of colostrum has been argued to have contributed to the fall in infant mortality in this period, and the widening of class differences in mortality (Fildes, 1988a). However no quantitative evidence of breastfeeding habits has been produced to substantiate the anecdotal literature.

Figure 4 suggested that there was heterogeneity in breastfeeding practices within the parish (evident in the hump of short birth intervals amongst infants known to have survived the first year of life 1752-74). However there was also considerable convergence in behaviour over the period to relatively long maternal breastfeeding, resulting in unimodal distributions of birth intervals (following the birth of infants known to have survived infancy) in the periods 1775-94 and 1795-1812. We can investigate the practices underlying these patterns more closely by analysing birth interval data by social status group. Unfortunately the smaller status groups 0 and 3, the wealthiest and paupers, were too small for meaningful analysis and so two groups were created of high (groups 2,3) and low status (0,1) families. In each case the distribution of birth intervals in the larger group (groups 1 and 2) was compared with the distribution for the combined social status groups using Kolmogorov-Smirnoff tests for equality of distributions. These confirmed that the larger group in each case did not differ significantly from the combined distribution, suggesting that the smaller group was not sufficiently different from its larger pair to alter the distribution.

Differences in birth interval distributions between the two status groups were striking, especially in the mid-eighteenth century (Figure 5).[13] With respect to infant feeding the most useful data are those birth intervals where the infant born at the opening of the interval was known to have survived the first year of life and so there was no early cessation of breastfeeding caused by infant death. In this case birth intervals amongst lower status families were distributed with a single peak at 21-24 months across the period 1752-94 (although there was a reduction in shorter birth intervals in the second period). These data suggested that maternal breast-feeding was the norm amongst lower status families, although the duration of feeding was less than that suggested by birth intervals in the 26 parish national sample. In contrast higher status families were associated with an apparently bimodal distribution with peaks at 14 and 24 months in the period 1752-74, indicating

[13] Social status differences in birth intervals and mortality could only be explored for the period 1752-94 when baptism fees were highly graduated.

substantial heterogeneity in feeding practices. Some proportion of higher status infants were apparently breastfed by their mothers for only a very short period or not at all, resulting in a cluster of birth intervals as short as was the case where the infant died within the first six months of life. However in the second period, 1775-94, birth intervals amongst wealthier families converged to a pattern resembling that of lower status families with a single peak at 23 months, suggesting a substantial increase in the prevalence and/or duration of maternal breastfeeding amongst wealthier families over the second half of the eighteenth century. Interestingly the heterogeneity of infant feeding practices evident in the higher status group in the mid-eighteenth century was a feature of families in the highest status group (group 3) as well as group 2 (as indicated by the lack of difference between birth intervals in group 2 and the combined groups 2 and 3), indicating that relative long breastfeeding was practiced by some significant proportion of mothers even the amongst the wealthiest ten percent of families in the sample.

The data presented in Figure 5 also point to significant differences in the extent of ‘missing infants’ between social groups. The distributions of birth intervals following the births of infants of unknown fate were relatively similar to those for infants known to have survived the first year of life in the lower status group, but significantly shorter in the higher status group. It was possible using regression analysis (see footnote 12) to adjust mortality for ‘missing’ infants by social status group (‘missing’ infants were calculated for each combined status group and then apportioned between status groups according to their relative share of infants of unknown fate in the combined group on the assumption justified above that birth interval distributions were similar in the two status groups within the combined group).

Adjusted neonatal mortality rates by social status group are presented in Table 7. Unadjusted rates suggested little difference in neonatal mortality by social status. However once the evidence for significant under-recording of burials amongst higher status groups was taken into account then a gradient in neonatal mortality by social status emerged. Under the most plausible adjustment (all missing infants assumed to have died) neonatal mortality in the wealthiest ten percent of families was more than double that of families paying only the standard public fee for baptism (group 1).

The higher mortality of neonates in high status families could be explained by the evidence of a lower prevalence of maternal breastfeeding in this group. However if this were the main cause of status differences in neonatal survival then one would expect a convergence in neonatal mortality rates by social status in the late eighteenth century consistent with the convergence to lengthy maternal breastfeeding suggested by birth interval analyses. However under the most plausible assumption (that missing infants died) there was almost no change in neonatal mortality in any group over the second half of the eighteenth century. The modest improvement in neonatal mortality in the sample as a whole in this period was a product instead of a change in the composition of the sample. The proportion of private baptisms diminished resulting in an expansion of Group 1-type families at the expense of group 2 (see sample sizes, Table 7, and Boulton & Davenport, 2013). Group 1 families were characterised by the lowest neonatal mortality rates of any status group and their increased representation in the sample from the 1770s lowered average neonatal mortality without any status-specific changes in mortality rates.

This conundrum, of an apparent increase in breastfeeding in early infancy without any impact on neonatal mortality, could be investigated further through consideration of the seasonality of neonatal mortality. In the national sample endogenous infant mortality was higher in winter months but seasonality was muted compared with mortality later in infancy (Wrigley et al., 1997: 336-7). However amongst London Quakers neonatal mortality demonstrated clear summer peaks which Landers interpreted to indicate the practice of hand-feeding of neonates and the increased risk of contamination of food in hotter weather.

In St. Martin's there was a clear summer peak in neonatal mortality and this summer rise in mortality persisted (and in fact became more pronounced) in the last quarter of the eighteenth century despite the evidence from birth intervals of an increase in early maternal breastfeeding (Figure 6). This phenomenon though puzzling was very similar to the patterns in breastfeeding and seasonality evident amongst London Quakers in the same period (Landers, 1993). When seasonality was decomposed by social status group (using combined status groups to increase sample sizes) then the summer peak of neonatal mortality was confined to high status families in the first period (1752-74) (Table 8). Taken together with the evidence of absence or short duration of maternal breastfeeding in a proportion of higher status families this suggested that some of these infants were hand-fed rather than wet-nursed (or that milk from wet-nurses was less effective than maternal milk in protecting infants from infections that were particularly prevalent in summer). However in the second period (1775-94) a summer peak in neonatal mortality also emerged amongst lower status families (although decomposition by pauper and non-pauper groups indicated that this effect was a consequence solely of high summer mortality amongst pauper neonates). The emergence of a summer peak in mortality of lower status infants, without any evidence of a change in breastfeeding practices in this group, suggests the possibility of the emergence of some new factor that was perhaps independent of feeding practices.[14] Alternatively and in tandem with increased maternal breastfeeding hand-feeding of infants may have been become more popular and was perhaps adopted even by some pauper families.[15] Fildes argues that an increasing aversion to wet-nursing drove a rise in both maternal breastfeeding and hand-feeding of higher status infants and points to the proliferation of infant feeding devices in this period. She also argues from the extensive survival of feeding vessels and the very varied range of materials used (from silver to the cheapest pottery) that their use must have been widespread with all sections of the population (Fildes, 1986: 348).

Neonatal mortality fell by a further third in the period 1794-1812 (adjusted on the assumption that all missing infants died, Table 5), resulting in an overall halving of neonatal mortality in the period 1752-1812. We cannot follow mortality by social status after 1794 except by a simple pauper/non-pauper distinction. The number of pauper births was very small (156), making this category virtually unusable. Table 7 suggests that there was a fall in neonatal mortality in both pauper and higher status groups, although the rate for paupers is very unreliable. The summer peak of neonatal mortality persisted in the sample as a whole at a slightly lower level than its peak in the late eighteenth century (Figure 6). The number of neonatal deaths in the pauper group after 1794 was only four so it was not possible to calculate a seasonality index by social status in this period (although the four deaths were

[14] It is unlikely however that such a factor would operate to maintain the observed social status differentials in neonatal mortality if unconnected with feeding practices. Moreover analysis of neonatal mortality amongst workhouse infants indicated that summer was a relatively healthy period to be born in throughout the period 1750-1824 (Davenport et al., 2012).

[15] In this case it would be necessary to argue that pauper neonates fed in this way usually died, in order to account for the lack of any evidence for early weaning in pauper birth intervals.

confined to winter months). If there were an abatement of some neonatal disease with greatest effect in summer, or a reduction in the popularity of infant hand-feeding, then this may have allowed the (delayed) emergence of the expected positive effects on survival of newborns of the apparent increase in maternal breastfeeding after 1775.

In summary, neonatal mortality in St. Martin in the Fields was strikingly similar to that of London Quakers both in the level and trend of mortality, and in the complex evidence of a rise in maternal breastfeeding with no concomitant reduction in the relative lethality of summer to neonates. When considered by social status it appeared that maternal breastfeeding was the norm in poorer families but that some proportion of higher status infants were probably weaned very early or never breastfed by their mothers. These status differences in breastfeeding were reflected in a status gradient in infant mortality. However although all status groups appeared to converge to some extent in breastfeeding practices in the late eighteenth century there was no convergence in neonatal mortality (and no reduction in the summer peak of neonatal mortality). Rather the modest reductions in infant mortality in the period before 1800 were a product at least in St. Martin's of a shift in the composition of the reconstitution sample towards those groups amongst whom maternal breastfeeding was already a long-established norm. These quantitative trends paralleled closely Fildes' qualitative evidence of a rise in both maternal breastfeeding and hand-feeding amongst higher status families in the late eighteenth century, and suggested that any improvements in survival as a consequence of increased levels or quality of maternal breastfeeding may have been undermined by a related rise in the lethal practice of hand-feeding newborns. On balance it appears that the higher rates of neonatal mortality in urban populations before the nineteenth century may have been a consequence of lower levels of maternal breastfeeding especially amongst higher status groups, and the greater dangers this posed to infants in a crowded and polluted urban environment. As maternal breastfeeding became the norm even amongst higher status families then this probably drove reductions in neonatal mortality although this effect was muted at least initially by other factors with greatest effect in summer. Importantly the evidence of a social gradient in neonatal mortality suggested that maternal nutritional status was not a major determinant of levels or trends in neonatal mortality, since the groups where mothers were most likely to have been well-nourished were those with the highest mortality (and where the fall in neonatal mortality may have been greatest). With respect to the 'epidemiological integration' hypothesis the evidence of the importance of infant feeding practices in explaining the excessive mortality of urban neonates and suggestive evidence that mortality decline may have been greatest amongst higher social groups seems sufficient to explain the fall in neonatal mortality in urban populations after 1750 against a background of intense and possibly intensifying infectious disease risk.

Further work will extend the analysis of the St. Martin's reconstitution to ages 1-23 months, where the data present a greater challenge to the 'epidemiological integration' hypothesis.

References

Table 1. Male occupations in St. Martin in the Fields and Middlesex

Sector	**St. Martin-in-the-Fields**	**Middlesex**
Occupations of grooms marrying at the Fleet registry, 1750-52, by groom's address.[16]		
Primary	1.9	9.9
Secondary	60.4	53.4
-clothing	15.2	6.9
-footware	12.0	6.8
Tertiary	35.3	32.2
-transport	14.2	16.6
Labourers	2.4	4.5
N	374	7393
Occupations of fathers of children recorded in baptismal registers 1813-18.[17]		
Primary	1.1	3.7
Secondary	51.5	39.2
Tertiary	40.1	39.4
Dealers	1.8	2.9
Sellers	8.0	6.8
services, professions	23.9	20.5
Transport and Communications	8.7	9.3
Other[18]	7.4	17.7
N	1048	95522

Table 2. Distribution of baptism fees and family social status in the parish and in reconstitution families, 1752-1794

baptism fee	**all baptisms**	**reconstitution family baptisms**	**reconstitution family social status**
0 (pauper)	11.4	6.9	11.4
1-39 pence	48.3	47.7	39.4
40-99 pence	23.6	28.4	37.2
100+ pence	4.3	5.6	10.1
not given	12.3	11.6	1.9

[16] Cambridge Group Occupations Project, ESRC RES-000-23-1579 and RES 000-23-0131.
[17] Data from a one-in-seven sample of the baptism registers of St. Martin-in-the-Fields, and complete or sampled registers for all Middlesex parishes, Cambridge Group Occupations Project (registers were sampled where the number of entries exceeded 2000 for the period 1813-18).
[18] This category includes labourers, who were not distinguished as agricultural or otherwise in the sources.

Table 3. Cumulative percentage distribution of burial fees in reconstitution families according to social status defined by baptism fees.

	social status			
burial cost (pence)	0 (pauper)	1 (1-39 pence)	2 (40-99 pence)	3 (100+ pence)
0	24.7	4.5	2.3	1.2
1-49	29.7	5.7	2.6	1.6
50-99	80.8	67.7	35.3	13.8
100-199	98.3	92.4	78.3	27.2
200+	100	100	100	100

Table 4. Age-specific mortality (probability of dying in age interval *1000) in reconstitution families (unadjusted rates for St. Martin in the Fields).

age (days)	**1752-74**[19]	**1775-94**[20]	**1795-1812**[21]
	St Martin in the Fields, unadjusted		
0-29 (neonatal)	68	40	31
30-364 (post-neonatal)	138	131	89
365-729 (age 1)	106	113	82
endogenous mortality[22]	57	31	30
	London Quakers		
0-29	96	81	40
30-364	256	163	160
365-729	150	101	93
endogenous mortality	43	48	27
	26 parish sample		
0-29	79	71	57
30-364	91	92	83
365-729	48	51	48
endogenous mortality	61	53	41

Sources: St. Martin in the Fields baptism and burial fee books; Landers (1993: 136); Wrigley et al. (1997: 226,236,252)

[19] 1750-1774 for London Quaker and 26 parish sample
[20] 1775-1799 for London Quaker and 26 parish sample
[21] 1800-1824 for London Quaker and 26 parish sample
[22] Calculated from biometric analyses: see text for explanation and Figure 3 for sources of rates for St. Martin in the Fields.

Table 5. Age-specific mortality (probability of dying in age interval *1000) in reconstitution families (adjusted and unadjusted rates for St. Martin in the Fields).

age (days)	**1752-74**[23]	**1775-94**[24]	**1795-1812**[25]
St Martin in the Fields, unadjusted			
0-29 (neonatal)	68	40	31
30-364 (post-neonatal)	138	131	89
0-364 (age 0)	197	166	117
365-729 (age 1)	106	113	82
St Martin in the Fields, adjusted (missing infants removed from observation)			
0-29	76	46	33
30-364	157	153	99
0-364	221	193	128
365-729	126	142	90
St Martin in the Fields (missing infants assumed to have died in the parish)			
0-29	99	75	51
30-364	244	249	155
0-364	318	306	198
365-729	126	142	90
London Quakers			
0-29	96	81	40
30-364	256	163	160
365-729	150	101	93
26 parish sample			
0-29	79	71	57
30-364	91	92	83
365-729	48	51	48

Sources: St. Martin in the Fields baptism and burial fee books; Landers (1993: 136); Wrigley et al. (1997: 226,252)

Table 6. Number of birth intervals analysed by social status and period of birth of the first child in interval

Status group	**1752-74**	**1775-94**
0 (paupers)	462	691
1	1273	2442
2	2709	1485
3 (wealthiest)	442	591

[23] 1750-1774 for London Quaker and 26 parish sample
[24] 1775-1799 for London Quaker and 26 parish sample
[25] 1800-1824 for London Quaker and 26 parish sample

Table 7. Neonatal mortality (days 0-29) in St. Martin in the Fields reconstitution families

	social status				
	0 (pauper)	**1**	**2**	**3 (wealthiest)**	**all**
Unadjusted					
1752-74	75	49	77	63	68
1775-94	51	30	53	50	40
1795-1812	26		31 (non-pauper)		31
adjusted (missing infants removed from observation)					
1752-74	76	50	91	86	76
1775-94	51	32	68	73	46
1795-1812	28		33 (non-pauper)		33
adjusted (missing infants assumed to have died in the parish)					
1752-74	77	51	116	130	99
1775-94	66	47	111	128	75
1795-1812	26		51 (non-pauper)		51
N (births)					
1752-74	663	1702	3267	557	6189
1775-94	720	3105	1254	774	5905
1794-1812	156		3878 (non-paupers)		

Table 8. Seasonal index of neonatal mortality by social status and period of birth

		1752-74		**1775-94**		**1795-1810**
				Social status		
season	**month**	**low (groups 0,1)**	**high (groups 2,3)**	**low (groups 0,1)**	**high (groups 2,3)**	**non-pauper**
winter	Dec-Feb	0.88	1.07	0.86	0.92	0.72
spring	Mar-Apr	0.81	0.76	0.65	0.95	0.94
summer	June-Aug	1.10	1.18	1.43	1.30	1.31
autumn	Sep-Nov	1.21	0.98	1.05	0.83	1.03

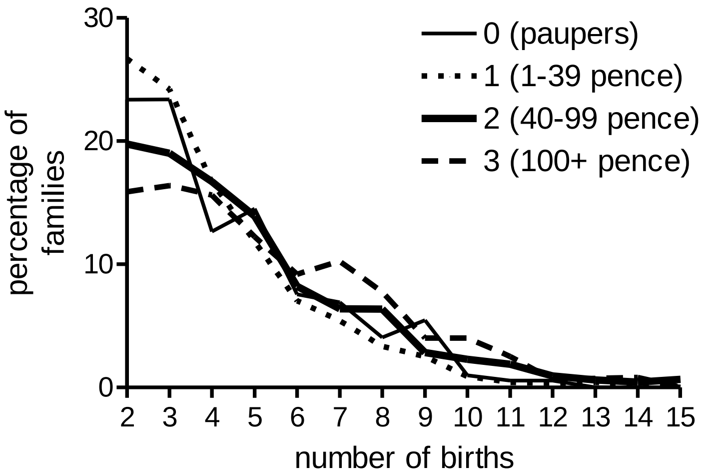

Figure 1. Distribution of number of births in families of social status groups (based on baptism fees).

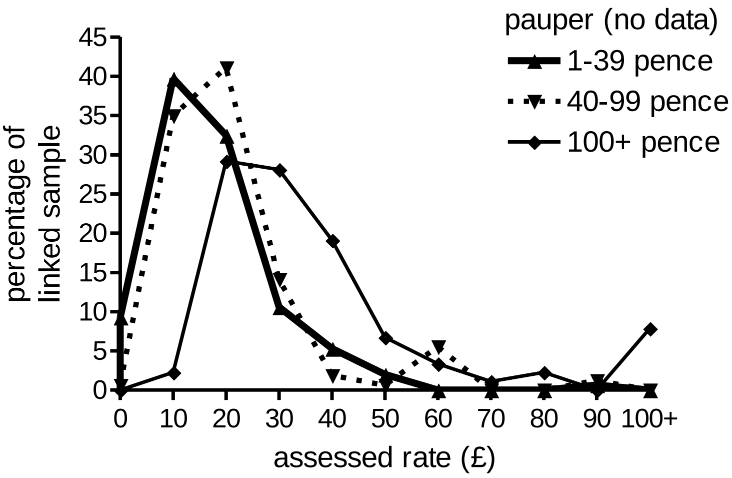

Figure 2. Distribution of assessed rates in 1784 by family social status (based on baptism fees).

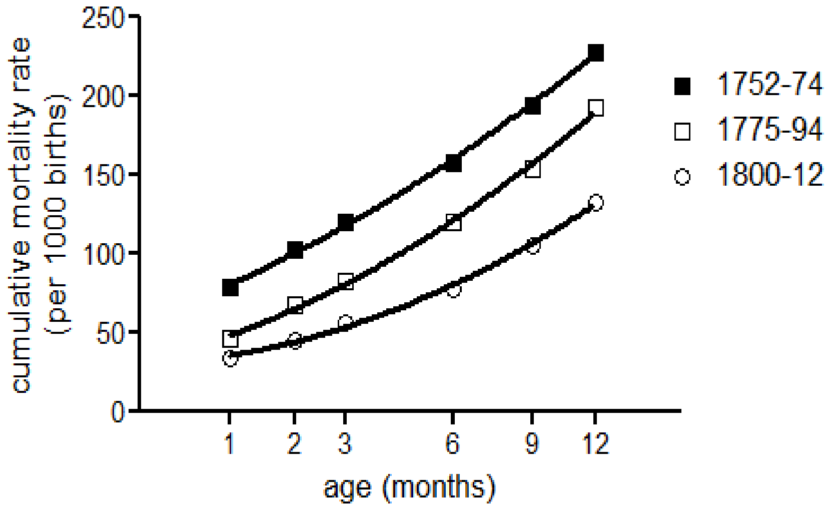

Figure 3. Biometric plots of (unadjusted) cumulative mortality over the first year of life in St. Martin-in-the-Fields reconstitution sample, fitted with second order polynomial equations.

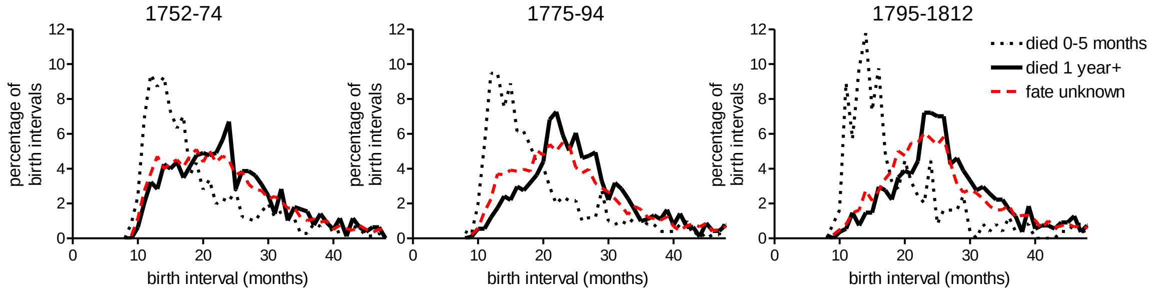

Figure 4. Birth intervals in St. Martin in the Fields reconstitution families according to the fate of the child born at the opening of the interval, by period of birth of first child in interval.

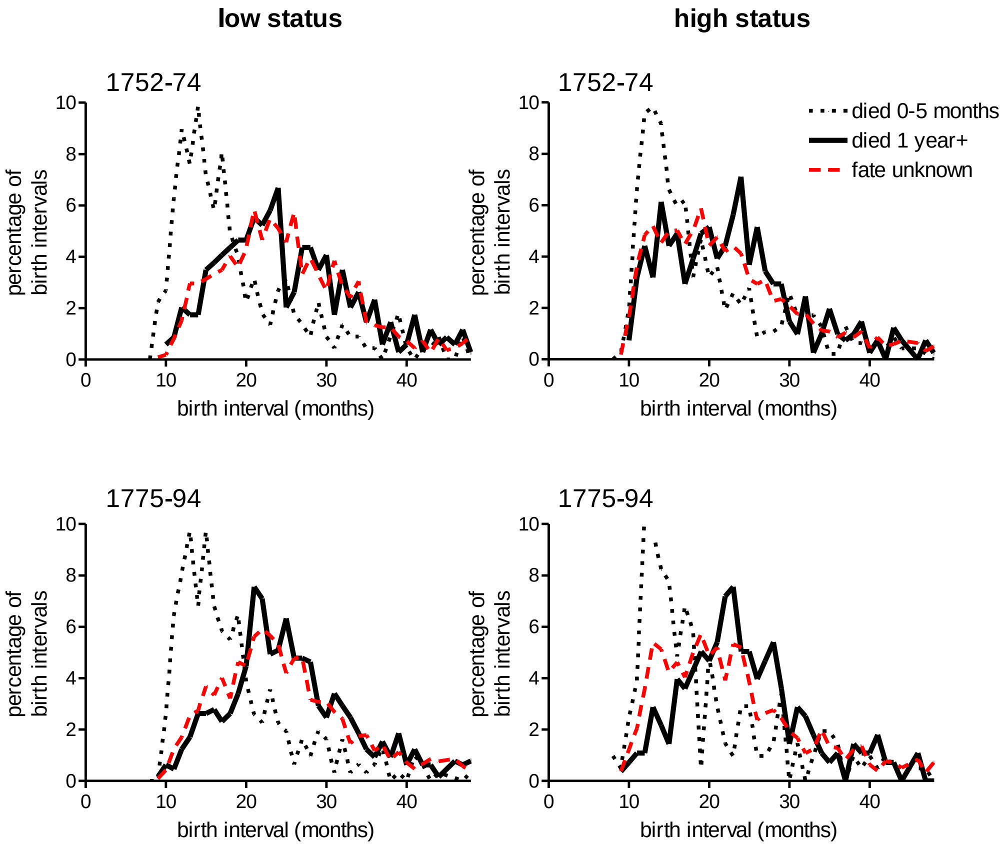

Figure 5. Birth intervals by period of birth of first child in interval and by social status of family. Low status families included groups 0 (paupers) and 1 (18 pence baptisms), high status families comprised groups 2 (42-60 pence private baptisms) and 3 (highest cost baptisms). Numbers of birth intervals are given in Table 6.

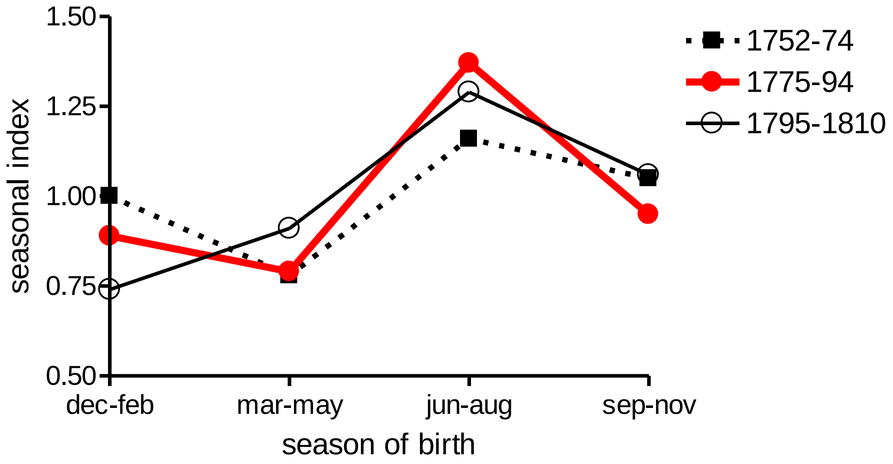

Figure 6. Seasonality index of neonatal mortality (by month of birth). Mortality rates were adjusted for length of month and seasonality of births and converted to a proportion of the annual mortality rate.