Infant and young adult mortality in London's West End, 1750-1824.

Romola Davenport[1], Jeremy Boulton[2] & Leonard Schwartz[3],[4].

Migration was a key component of the demographic regime of London in the eighteenth and nineteenth centuries. It is probable that a regular inflow of migrants was required to balance the high urban mortality rates and maintain the population of London until at least the late eighteenth century. While there is strong evidence of high urban mortality in infant mortality rates and in the large excess of burials with respect to baptisms in city registers, relatively little is known about adult mortality in the capital, and even less is known about the mortality risk of migrants themselves. Migrants may have been at higher risk of mortality than native-born Londoners if they experienced poorer living conditions, as a consequence of residential segregation and low socioeconomic status. However migrants may also have differed from the native-born population in their susceptibility to certain diseases as a consequence of their immune status prior to migration. The immune status of immigrants could have made them more vulnerable or possibly more robust than their urban-born peers, depending on the nature of the diseases they encountered, and the epidemiology of their native environment.

McNeill (1980) proposed that, as epidemic diseases became endemicised in large populations, dense urban populations would experience increasingly frequent epidemics, producing high levels of immunity amongst adults. In less densely populated and more remote areas, epidemics would remain infrequent, resulting in large numbers of immunologically 'naïve' adults. McNeill's hypothesis applies only to those diseases which are transmitted directly from person to person and which confer long-lasting immunity on survivors (such as smallpox and measles). A consequence of McNeill's argument is that, during this phase of endemicisation, rural migrants to urban areas would be at high risk of epidemic disease relative to the native-born population, amongst whom such diseases would have become confined mainly to childhood. As population densities rose and contacts between rural and urban areas increased then the frequency of epidemics would increase nationally, until these epidemic diseases became endemic diseases of childhood throughout the population. Endemicisation at the national level is thought to have occurred during the eighteenth century in England, resulting in high infant and child mortality rates and falling young adult mortality rates over the century. In particular, exogenous infant mortality, attributable largely to infectious diseases, peaked in the mid-18th century, while endogenous infant mortality (reflecting conditions *in utero* and during birth) fell, together with declining maternal mortality. This pattern is consistent with improving young adult health as immunity of this age group to epidemic diseases rose, and increasing infectious disease mortality in children and infants as the same epidemic diseases became endemic in the population.

---

[1] Cambridge Group for the History of Population and Social Structure.
[2] University of Newcastle
[3] University of Birmingham
[4] This project was funded by the Wellcome Trust (award no. 081508). Data were transcribed and cleaned by Drs. John Black and Peter Jones.

In urban populations, McNeill's thesis predicts that during the process of endemicisation, epidemic disease mortality should become increasingly confined to children and young adult migrants from rural areas. At some point however the immunological distinction between rural migrants and the urban-born should disappear, as epidemics became more frequent and widespread nationally.

An alternative scenario is the 'migrant selectivity' hypothesis, that migrants to urban areas constituted a 'selected' subpopulation of healthy, low risk individuals. In this case, the selection effect could have operated in two ways: only the more robust rural dwellers would have chosen to migrate; and those migrants who fell ill may have been more likely to return to their place of origin, perhaps to access institutional or informal support that was not available to them in the city.

The two hypotheses are not mutually exclusive: cities could have attracted the most robust rural immigrants, who then fell victim to the endemic diseases of urban areas. However they do produce different predictions with respect to the age patterns of different causes of death. McNeill's hypothesis predicts that infectious diseases that confer immunity should be concentrated in young children and young adult rural immigrants. The migrant selectivity hypothesis predicts that especially chronic disease mortality should be lower in migrants (since chronic diseases would both prevent migration and induce migrants to return home, whereas acute diseases would not allow these deliberate responses).

For London, McNeill's hypothesis was tested by John Landers, using the London Bills of Mortality and two reconstitutions of London Quaker meetings for the seventeenth and eighteenth centuries (Landers, 1987; Landers, 1993). The Bills of Mortality contained information on cause of death and age of death, but these variables were not cross-tabulated. Therefore Landers used a statistical technique, z-score correlations, to estimate the age patterns of specific diseases. He assumed that most migrants to London were adolescents and young adults, and found that smallpox was the only disease that was strongly associated with child and young adult deaths. Thus smallpox appeared to fit the predictions of McNeill's model: it occurred in frequent epidemics, and killed mainly children and the age groups most likely to contain new migrants – adolescents and young adults. Although migrants could not be identified directly in either of Landers' sources, the Quaker reconstitutions supported the argument that deaths amongst adolescents and young adults were confined to migrants, since Landers could not trace any smallpox victims aged over 10 years to a baptism record, suggesting that they were not native to London. Moreover, smallpox was the only disease group that Landers found to be associated with grain prices in the capital (Landers, 1986). Since smallpox susceptibility is not known to be associated with nutritional status, Landers argued that the increase in smallpox deaths associated with higher food prices was a consequence of increased migration into the capital during periods of hardship in rural areas, bringing an influx of susceptibles into the population, as well perhaps as increasing the transmission of smallpox (the latter was perhaps a necessary argument in view of the rise in child deaths in years of high grain prices, given Landers' assumption that migrants in these years remained predominantly single young adults). Using a different statistical technique, Galloway (1985) found that deaths from 'fevers' as well as smallpox were associated with grain prices. Since Landers found 'fever' mortality to be associated with young adult deaths, it is possible that some of the causes of death subsumed in 'fevers' would also fit the McNeill model in afflicting mainly migrant adults.

Evidence for the superior health of migrants in this period comes mainly from anectdotal sources. Rural women were often claimed to be healthier and stronger than their urban-born peers, and therefore more desirable as servants (Sharpe, 2000). Additionally, rural recruits were notably taller than their London-born counterparts (Floud et al. 1990).

Migrants are an unusually difficult group to study, even in modern populations. They are usually excluded from family reconstitutions, because they are not well documented in parish records. Migrants lack baptism records and so cannot be assigned an age. Migrants may also be less likely to marry and reproduce, and are therefore under-represented in marriage and baptism registers. The high numbers of migrants in urban populations is one reason for the paucity of historical demographic analysis of urban populations (another critical factor being the high degree of short distance migration between parishes within cities). Where burial data by age exist, as in the London Bills of Mortality, then it is still not possible to identify migrant burials specifically. The historical demography of young adults is also relatively poorly understood, for similar reasons. Due to the relatively late age at marriage in the English population, and the mobility of young adults before marriage, parish registers contain relatively little information on these age groups, and model life tables are often used to extrapolate mortality rates between childhood and marriage age (as Landers did with the London Quakers). The sextons' books of St Martin in the Fields therefore represent a very unusual opportunity to study some aspects of migrant and young adult mortality in London over the period 1750-1824. The dataset comprises burials in the parish of St Martin in the Fields identified by age, sex, cause of death, street address and cost of burial. This therefore provides the basis to test directly the associations between age and reported cause that Landers could only crudely estimate. Moreover the cost of burial data make it possible to identify a subgroup within the population, paupers, in which migrants were probably concentrated, as argued below. Differences in causes of death between paupers and other burial cost groups can be used, with caution, to infer differences in disease susceptibility between migrants and the native-born population. The period of the dataset overlaps the early censuses and it is therefore possible to estimate the age structure and age-specific mortality rates of the population of St Martin's at least for the early nineteenth century. Although age-specific mortality rates can't be calculated with much confidence for the eighteenth century, the cause of death data are of higher quality for this period (1750-99) than for the early nineteenth century, and these can be used to estimate the age and sex specificity, as well as differences in cost of burial, of disease groups. The St Martin's population and burial data are described below, and the rationale for attributing migrant deaths principally to the pauper category is explained. The burial patterns are then analysed to test whether there is any evidence for a process of endemicisation as described by McNeill, or for a selectivity effect, with respect to both infant and maternal mortality, and young adult mortality in general. The paper contains only minimal discussion of adjustments to and limitations of the dataset, for reasons of space and clarity.

1. The St Martin in the Fields population in the early nineteenth century.

One of the most serious problems in using historical burial data is the lack of information on the population at risk, that is, the size and age structure of the population that gave rise to the burials. Changes in the size or age structure of the population at risk can cause changes in burial numbers that may be misinterpreted as changes in death rates (deaths per thousand at risk). No data on the age distribution of the St Martin's population exist before the mid-nineteenth century, and therefore it was necessary to estimate these values, in order to estimate age-specific death rates.

Population

St Martin in the Fields was a large parish (with a census population of 25,752 in 1801) and was relatively wealthy, with a high demand for especially female domestic labour, which was likely to have been met largely by extra-urban migration. There are no data on size or age structure of the population before the nineteenth century, and only limited information before the mid-19th century. The total population was reported by sex in decennial censuses from 1801. The census population fluctuated within the range 23,700-28,200 between 1801 and 1851, with no overall growth. The age structure of the St Martin's population was not reported before 1851, but the age structure of the Westminster district (of which St Martin's formed approximately 16% of the population in 1821) is available for 1821 (Fig. 1a). The age and sex pattern of the Westminster population was very similar to that of other parts of London in 1821 and to the age structure of St Martin's in 1851 (Fig. 1a,b). All the London populations show a distinctive peak in the young adult age groups, which is typical of labour migration, and which is absent in the national population. Additionally, the 1821 populations show a surplus of females over males especially in the young adult age groups, which reflects the influx at these ages of migrants for domestic service, which was dominated by women (Schwarz, 1992). The 1851 census described 22% of females aged 20 and over as domestic servants in London (Schwarz, 1999). This female surplus was less pronounced in St Martin's in 1851, but was probably a more significant feature of the population earlier in the period, as suggested by the rising trend in sex ratios. The sex ratio (male:female) of the St Martin's census population rose from 0.88 in 1801 (identical to the sex ratio of Westminster in 1821) to 0.92 in 1851. This increase in the sex ratio of the population of the population may be a phenomenon of the eighteenth century as well. The sex ratio of the St Martin's burials was heavily female in the 1750s but rose steadily over the period to 1824, and this may be related to a gradual masculinisation of domestic service over the eighteenth century (Schwarz, 1992). The similarities in the age structures of the London populations in 1821 and St Martin's in 1851 make it plausible to use the Westminster age and sex structure in 1821 as a model for that of St Martin's in the early nineteenth century.

Figure 1 also includes the age structure of the London population predicted by John Landers, which estimates a much older and more fertile population than is likely given the evidence from the other sources in Figure 1. This was a consequence of the model life tables used by Landers (Princeton models North and South), which assume relatively high young adult mortality and therefore underestimate the size of the young adult population when applied to the numbers of deaths in this age group. This issue is discussed further in the next section.

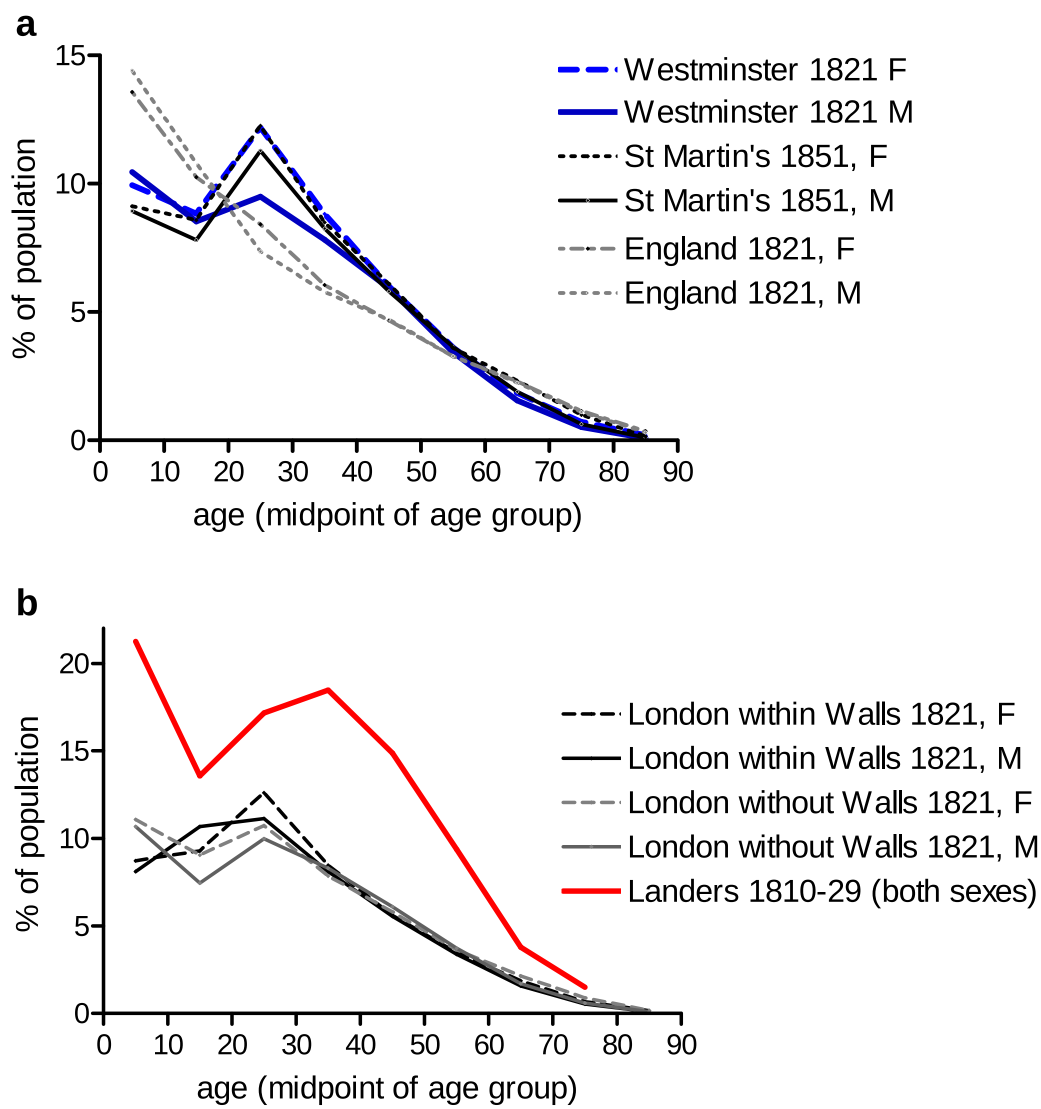

Figure 1. Age structure of London and English populations ca. 1821, and St Martin in the Fields in 1851. The populations are plotted by sex as a percentage of the total (sexes combined) by 10 year age groups, except for the estimates of the London population made by Landers for 1810-29, which are for both sexes combined. All data derive from published census material, except for Landers' estimates, which derive from application of model life table rates to the Bills of Mortality deaths (Landers 1993, table 5.8, p.180).

Age-specific mortality rates

Age-specific mortality rates (ASMRs) require both the number of deaths and the population at risk to be known. Age-specific mortality rates for St Martin in the Fields are only available from the 1850s, and age-specific mortality rates for London as a whole were first reported in 1841 (Fig. 2a: ASMRs for St Martin's in 1821 and 1801 are included in this panel for comparison, and their derivation described below). The most striking feature of the mortality rates for London and St Martin's in this period is the low mortality rates of young adults relative to other age groups. As shown in the model life table data included in figure 2b-c , national populations almost invariably show a 'trauma hump' of young adult mortality, where rates rise steeply in late adolescence, rise more slowly during young adulthood and then accelerate approximately exponentially from around 40 years of age. However the urban populations in figure 2a show no comparable 'hump' in early adulthood. There are obvious problems with both the St Martin's and the London series reported by the Registrar General, for instance the clear evidence of age heaping in the 'step' pattern of the Metropolitan ASMRs, and the likelihood that especially the female population at risk in early adulthood was exaggerated. However, adjusting for such exaggeration using either the correction factors suggested by Lee & Lam (1987) to the 1821 and 1841 censuses, or more extreme assumptions (and assuming no comparable misreporting of deaths in these age groups) did not inflate young adult mortality sufficiently to resemble the typical pattern. Rather it seems likely that this relative advantage of young adults in the capital was genuine. Since this is also the age group (15-39) where migrants were concentrated, the patterns suggest that young adult migrants were unusually healthy relative to the urban-born population at other ages, and possibly also compared to the national average (see below). Moreover, females in this age range did not experience the disadvantage relative to males that is evident in the national-level life tables for this period (data not shown). Since some of this disadvantage derived from maternal mortality, the difference may partly reflect the lower fertility of migrants. However the female disadvantage at ages 10-39 nationally was probably due mainly to high tuberculosis mortality, which was concentrated in this age range in females by the 1840s (when national cause-specific data was first consistently reported) but had an older age distribution in males. The female advantage in the capital suggests that female migrants may have had lower rates of tuberculosis, or may have been more likely to return home to die once ill with the disease.

To estimate ASMRs for St Martin's in the early nineteenth century, two methods were used. In the absence of direct knowledge of the population at risk, mortality rates can be estimated from the known deaths either by fitting a set of mortality rates from a model life table to the deaths, or by using an estimated population as the denominator to calculate the rates. The only rates that can be calculated directly are the infant and maternal mortality rates, where the number of births or baptisms is known. When the first method is used, a model life table is first identified, that matches the infant mortality rate and that predicts the expected total population size correctly. In the case of St Martin's none of the model life tables derived from national life tables (including the Princeton and UN models, as well as the English life tables of the Registrar-General and Wrigley & Schofield) could be made to fit the known burials in the early nineteenth century, when the total population size is known. In every case the age structure predicted was older than was plausible, given the estimates of age structure discussed in the previous section.

All the model life tables assumed a 'trauma hump' of young adult mortality, that therefore underestimated the size of the young adult population when compared with the estimates derived above from census data (above).

The second method, of using estimates of population age structure to calculate mortality rates, produced age patterns of mortality for the first quarter of the 19th century that were strikingly similar to those of the London and St Martin's populations in the mid-nineteenth century (Figure 2a-e). The total population size of St Martin's was derived from the census reports, and the size of each age class calculated by assuming the age and sex structure of the 1821 Westminster population. As for the mid-19th century, the early nineteenth century ASMRs calculated in this way indicate relatively low mortality rates for young adults and little female disadvantage. Comparison with mortality rates based on the modified 3rd English life table, level 10, constructed by Farr and modified by Wrigley & Schofield to represent national mortality in the mid-19th century, suggests that mortality was higher amongst children and older adults in St Martin's, but that young adults were at an advantage with respect to the national population by the 1820s (Fig. 2b). However adult mortality rates from the Cambridge Group reconstitutions for 1800-09 were lower than those estimated for the St Martin's population in the same period, perhaps indicating the persistence of an 'urban mortality penalty' for young adults in this period (Fig. 2c). Taken together the lack of a young adult trauma hump in the St Martin's ASMRs and the relatively low mortality rates in this age range are suggestive of a 'healthy migrant' effect.

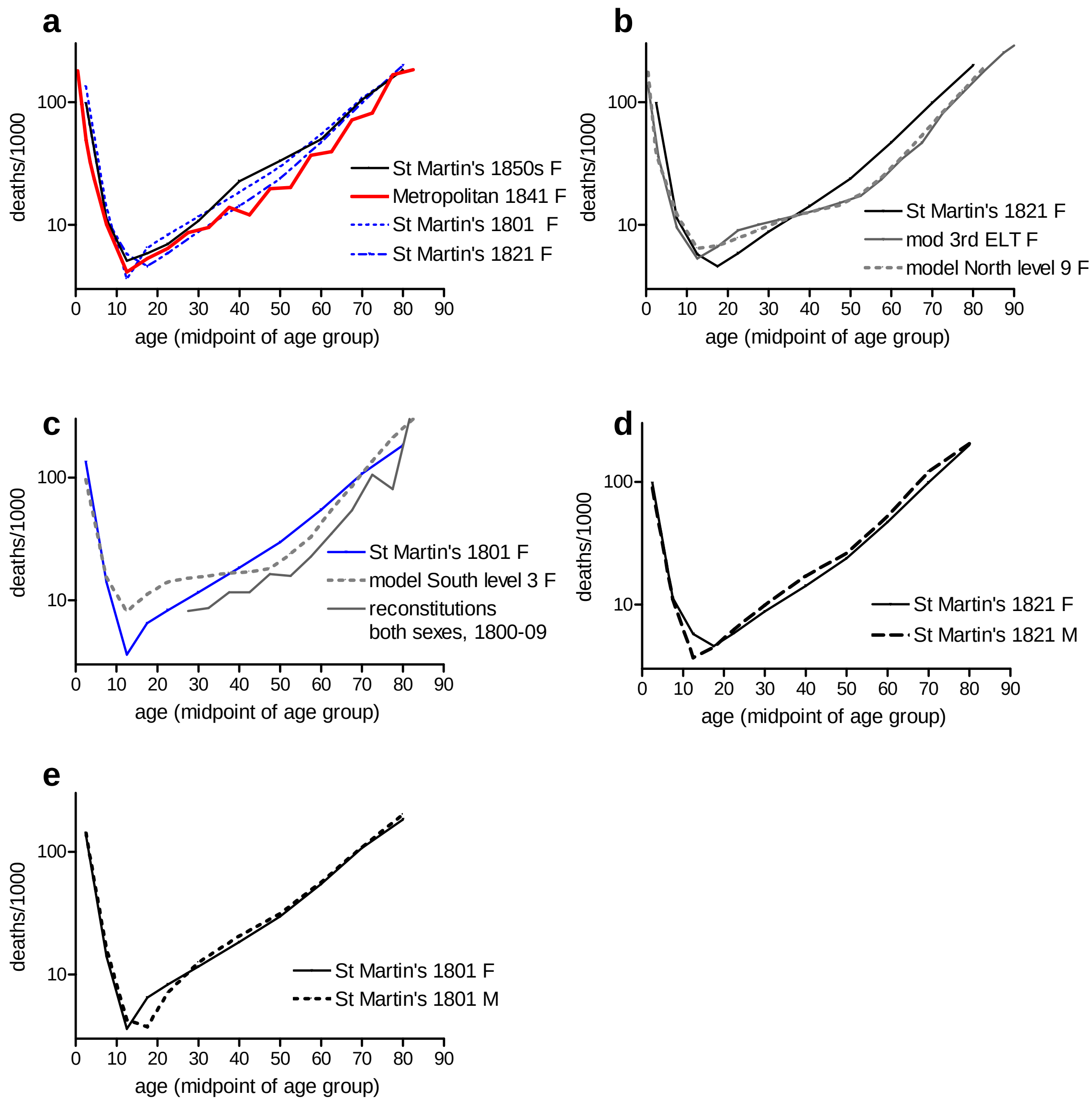

Figure 2. Age-specific mortality rates for London and national populations. 'F' refers to female, 'M' to male rates. London mortality rates derive from the sex-specific Metropolitan rates published in the 5th Annual Report of the Registrar-General for 1841 (p. xxvi). St Martin's rates for the 1850s were calculated from the decennial count of deaths and population reported in the Supplement to the 25th Annual Report of the Registrar-General, 1864. Rates for St Martin's in 1801 and 1821 were estimated from the average burials in the 5 year period centred on the census date, and the census population in those years, assuming the same age structure as reported in the 1821 census for Westminster. Panel b includes the modified English life table level 10 ('mod 3rd ELT') constructed by Wrigley & Schofield from Farr's 3rd English life table for the 1840s (Wrigley & Schofield, 1989). Panel c includes ASMRs calculated from the adult q_x values for the Cambridge Group reconstitution populations for 1008-09 (Wrigley et al., 1997, table XXX p. XX). Also shown are the mortality rates for the Princeton model life tables corresponding most closely to the IMR and population totals for St Martin's in those years. Note the log scale on the y-axis.

2. The St Martin in the Fields population in the second half of the eighteenth century.

Before the mid-nineteenth century neither the size of the population nor the number of deaths is known directly. However the patterns of burials by age and sex give some indications of the possible changes in age structure and/or mortality rates over the period. The data presented here include stillbirths, and have not been 'corrected' for under-recording – these issues are discussed briefly later. Comparing baptisms and burials in St Martin's, burials exceeded baptisms by a substantial margin from the late 1760s to ca. 1800 (Fig. 3). The baptism series is fairly flat, while the burial series shows large fluctuations, and mortality appears especially severe in the 1770s. The 1770s were also a period of extremely high IMRs (see later for the calculation of IMR), however the rise in burials cannot be accounted for only by a rise in infant mortality relative to other ages, because the infant proportion of burials in fact declined gradually over the whole period 1750-1824. Rather there was a rise in burials at all ages from 1750, although the peak period was not the same for all age groups (perhaps partly due to the large number of 'age unknown' burials in the late 1760s and early 1770s) (Fig. 4). These data could be interpreted as a general worsening of mortality (as was the case for infants), or a rise in population size. The latter explanation is probably untenable, given that there is a roughly synchronous rise in burials at all ages, which is not compatible with population growth through increased fertility (which anyway is not indicated in the baptism series) or migration, which tends to be age-selective. However there was some hint of a cohort effect in the adult burial ages, with burials at younger ages tending to peak and decline earlier, which perhaps suggests a transient rise in young adult immigration early in the period, that then inflated older age classes in subsequent decades.

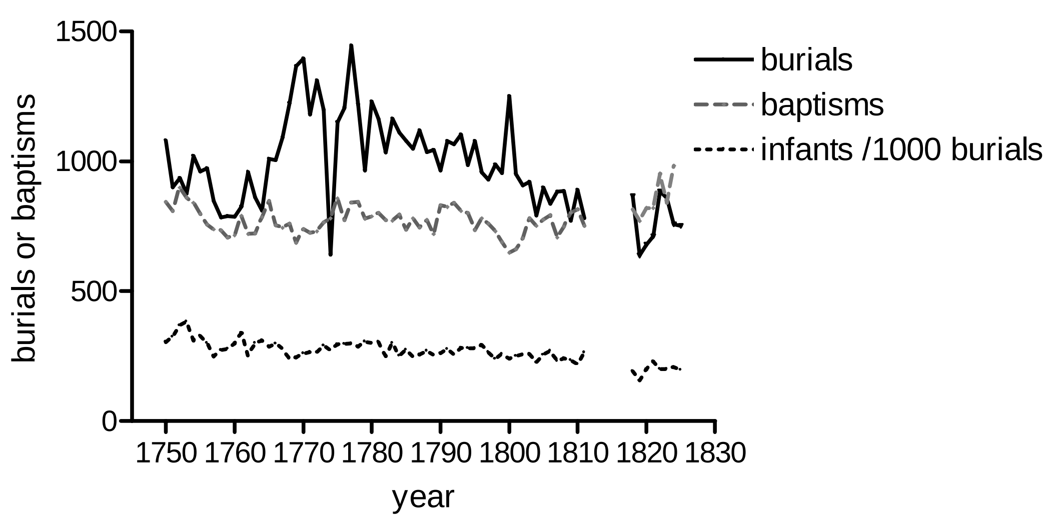

Figure 3. Annual burials, baptisms, and infant proportion of burials in St Martin in the Fields. All series include stillbirths, and no correction factors have been applied. The years 1812-17 are excluded, due to poor recording of burial numbers.

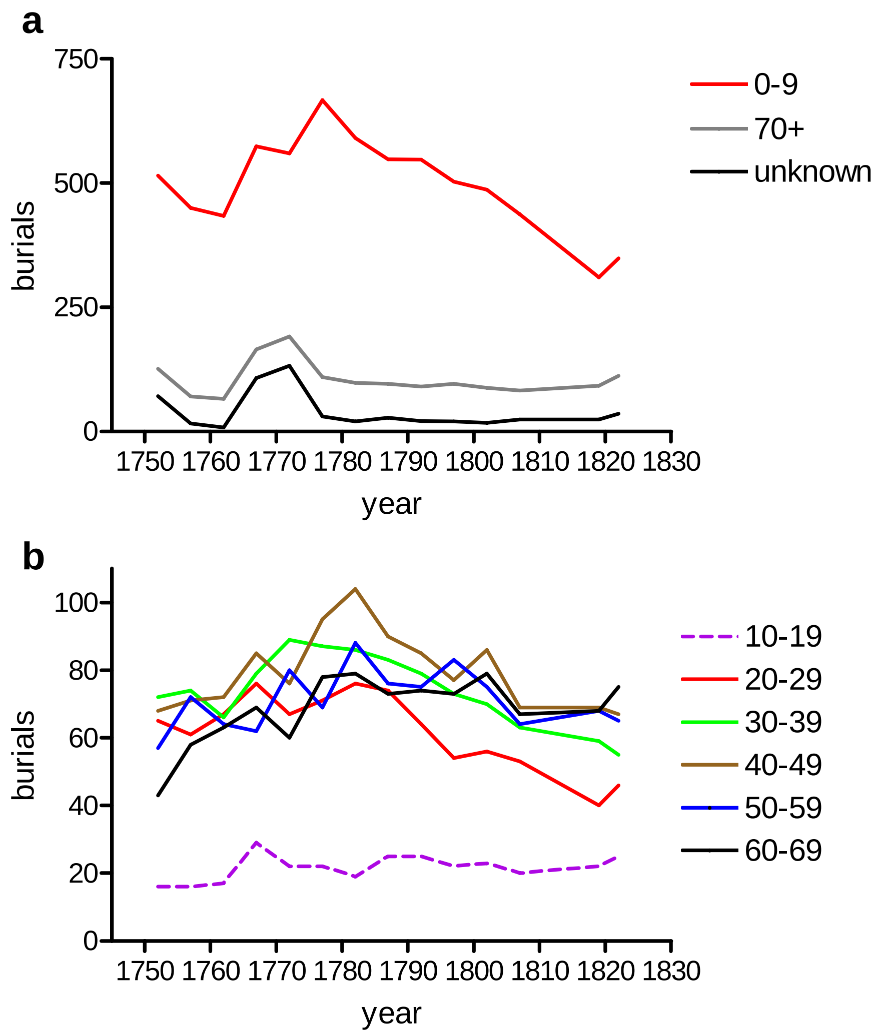

Figure 4. Five year averages of numbers of burials in St Martin in the Fields by 10 year age groups 1750-1825 (plotted at the midpoint of each five year interval). The period 1812-17 is excluded, so the last two periods are 1818-20 and 1821-25. Stillbirths are included in infant burials.

The sex ratio of burials (male:female) rose continuously over the period, as a result of changes in the sex ratios at adult ages (Fig. 5). These changes indicate a change either in the sex ratio of the underlying population (due for instance to changes in the number of female immigrants, or in the sex ratio of immigrants), or an improvement in female mortality relative to male. The rise in the sex ratio was steepest at ages 30-49, and was fairly muted at oldest adult ages. If the rise in the sex ratio over the period were due to a relative decline in female immigration, then younger age groups should reflect these changes first (since these are the age groups where recent immigrants were concentrated), while older ages, composed of London-born and earlier cohorts of immigrants, would mainly reflect the earlier migration regime (and intervening sex-specific mortality and emigration rates). While sex ratios are likely to fluctuate at younger ages due to the low numbers of burials (low mortality rates) in the youngest adult age groups (10-29), the fluctuations in the age range 10-39 appear synchronised, suggesting that they may represent actual changes in either migration rates or mortality by sex. Since there is little evidence of a rise in the sex ratio before 1800 in the age groups 10-29, the more protracted rise at ages 30-49 probably represents either an improvement in female mortality at these ages relative to male, or an increase in the rate of emigration of older female migrants.

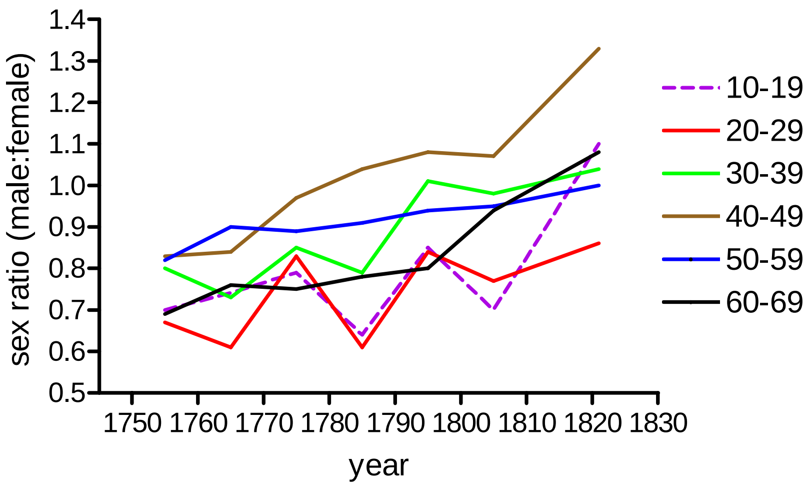

Figure 5. Sex ratios of burials in St Martin in the Fields by 10 year age groups for ages 10+, 1750-1825, calculated by five year intervals (plotted at the midpoint of each five year interval). The period 1812-17 is excluded, so the last two periods are 1818-20 and 1821-25.

To generate estimates of ASMRs for the eighteenth century, when no population totals were available, again either the age pattern of mortality could be assumed (using a suitable model life table), or the age structure of the population could be assumed. It was possible to construct a new model life table based on the St Martin's ASMRs derived for 1801-09 and 1820-24, but this method was of little use in determining whether the age pattern of mortality had changed over the second half of the 18th century, since it assumed a relatively fixed relationship between mortality at different ages. The second method assumed that the age structure remained invariant (and the same as that of Westminster in 1821), and used three levels of crude birth rate to estimate the population size (25, 30 and 35 births/1000). Interestingly, this approach produced a shift in age pattern over time, from one with a trauma hump of mortality in young adulthood (most marked in the 1750s) to one with low relative mortality at these ages (Fig. 6). Otherwise, there was only slight improvement at other ages, until the early nineteenth century. In addition, the sex ratio of mortality shifted from one of female advantage in the nineteenth century to a female disadvantage in the 1750s-1780s. However these patterns are highly dependent on the assumption of a constant age and sex structure, and population size. Changes in population size or the birth rate would reduce or inflate mortality rates at all ages. If female immigration rates were higher in the eighteenth century, then the sex ratios of ASMRs would be more favourable to females, and the female 'trauma hump' would reduce or disappear. However, the trauma hump appears to be of similar magnitude in both male and female ASMRs in the early decades, so the size of the young adult population would need to be similarly underestimated in both sexes to eliminate the trauma hump in both sexes.

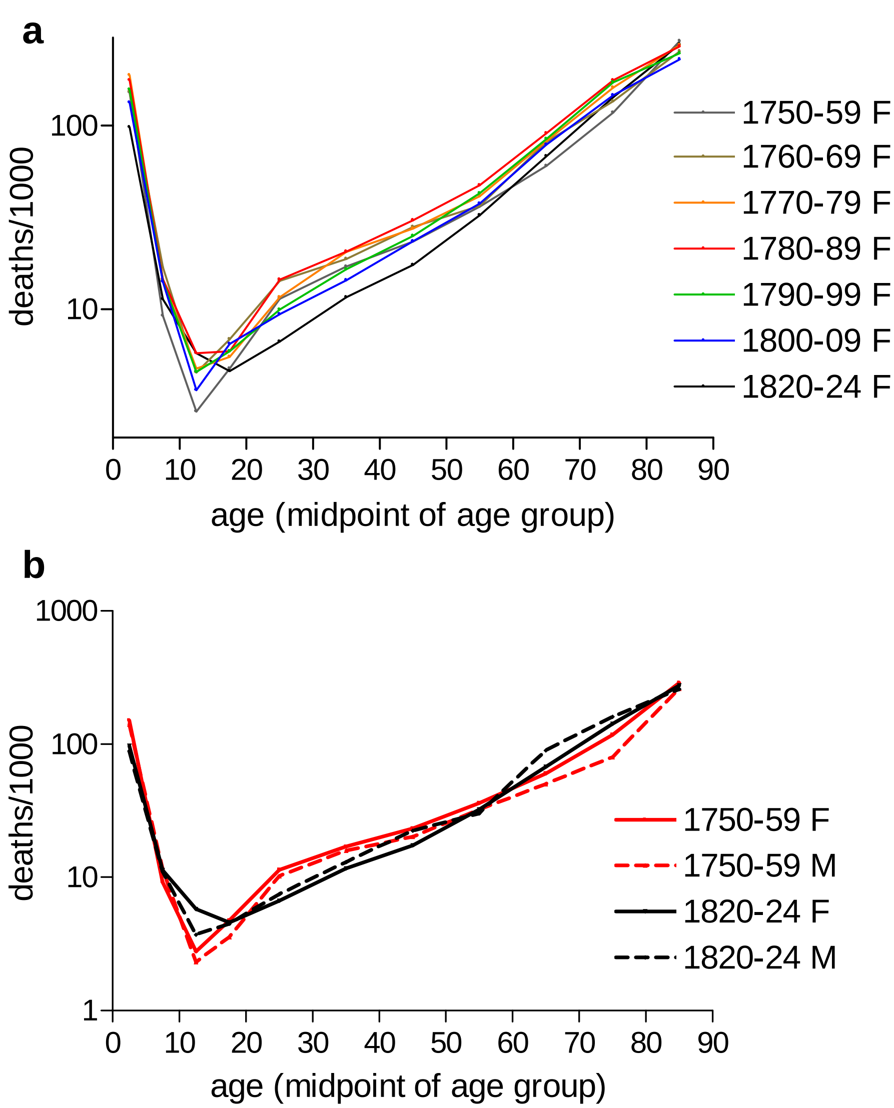

Figure 6. Decadal age-specific mortality rate estimates for St Martin in the Fields. Estimates were based on the assumption of a constant age and sex structure equivalent to that of Westminster in 1821. Estimates were calculated for years 1750-99 assuming a population size consistent with a crude birth rate of 30/1000, and for 1800-24 using the census population of St Martin's in 1805 (obtained by geometric extrapolation between census dates) and 1821. Age groups are represented in 5 year intervals from 0-19 (which mutes the changes in IMR) and in ten year age groups for older ages. Note the log scale on the y-axis.

Attempts to calculate ASMRs for St Martin in the Fields suggested that young adults in the parish were at an unusual advantage with respect to other age groups throughout the first half of the nineteenth century, and females were at especially low risk. This advantage was probably due to the large contribution of migrants to this age group, who were more robust than their urban-born counterparts, and probably also with respect to their non-migrant rural peers. Estimates of ASMRs for the latter half of the 18th century tentatively suggest that this young adult advantage either existed throughout or emerged sometime in the period 1750-1799.

Two other approaches were used to assess whether young adult mortality improved over the second half of the 18th century. The first approach used maternal and endogenous infant mortality as indicators of young adult health status. The second used the cause of death and burial cost data to assess whether migrants were especially at risk in the 18th century, and included the argument that migrant burials were predominantly pauper.

3. Infant and maternal mortality.

Infant mortality

Infant and maternal mortality rates can be calculated directly from burial data in conjunction with baptisms, once appropriate corrections have been made. Baptisms and infant burials are usually considered more subject to under-recording than burial totals for other age groups, due to omission of pre-baptismal infant deaths, in addition to more general effects of religious non-conformism and non-observance. However the rates reported here are based on uncorrected burial and baptism totals (except for the addition of stillbirths to both totals), for reasons described only briefly here. First, application of the correction factors used by Wrigley & Schofield (1989) and Landers (1993) produced high crude birth rates (CBRs) in the census period, which were similar to the national CBRs calculated by Wrigley and Schofield for the same period, but much higher than the crude birth rate reported for St Martin's by the Registrar-General for 1838-41 (of 24 births/1000 population). The uncorrected baptism rate produced crude birth rates much closer to that of the Registrar-General's (around 27/1000 for the early 1820s). The effect of the correction factors on IMR estimates was small (compared to uncorrected rates that excluded stillbirths), as the effects of corrections to the baptisms and burials tended to cancel each other. With respect to pre-baptismal infant deaths, it appeared that these were probably not usually unrecorded, but were recorded as stillbirths. The burial records gave ages of infants at death, and biometric (Bourgeois-Pichat) analysis of these ages indicated that almost no deaths were recorded under the age of one week, but that when stillbirths were included as neonatal deaths then the deficit of early deaths was compensated to some extent (Fig. 7). There was some evidence of a remaining shortfall in early deaths, that diminished progressively over the period. Since existing correction factors assume a rise in under-recording of early neonatal deaths over this period, biometric analysis of the St Martin's data did not justify their application. Instead, burials recorded as stillbirths were included in both the baptism and burial totals. No corrections were made for the effects of non-observance and non-conformism, and this may have caused under-estimation of both birth and death rates. However St Martin's may have been an unusually Anglican parish. In the marriage returns for 1851, where marriages are reported by denomination, only 1.7% of the marriages in St Martin's in that year were non-Anglican (of these, 4/13 were other Protestant denominations, and 9/13 took place in the Registrar's office) (14th Annual Report of the Registrar-General for England and Wales, Abstract of Marriages: 6). If these data in any way correspond to burial and baptism practices earlier in the century (when non-conformism was at its height according to Wrigley & Schofield), then St Martin's would have experienced very low rates of under-recording due to non-conformism and non-observance.

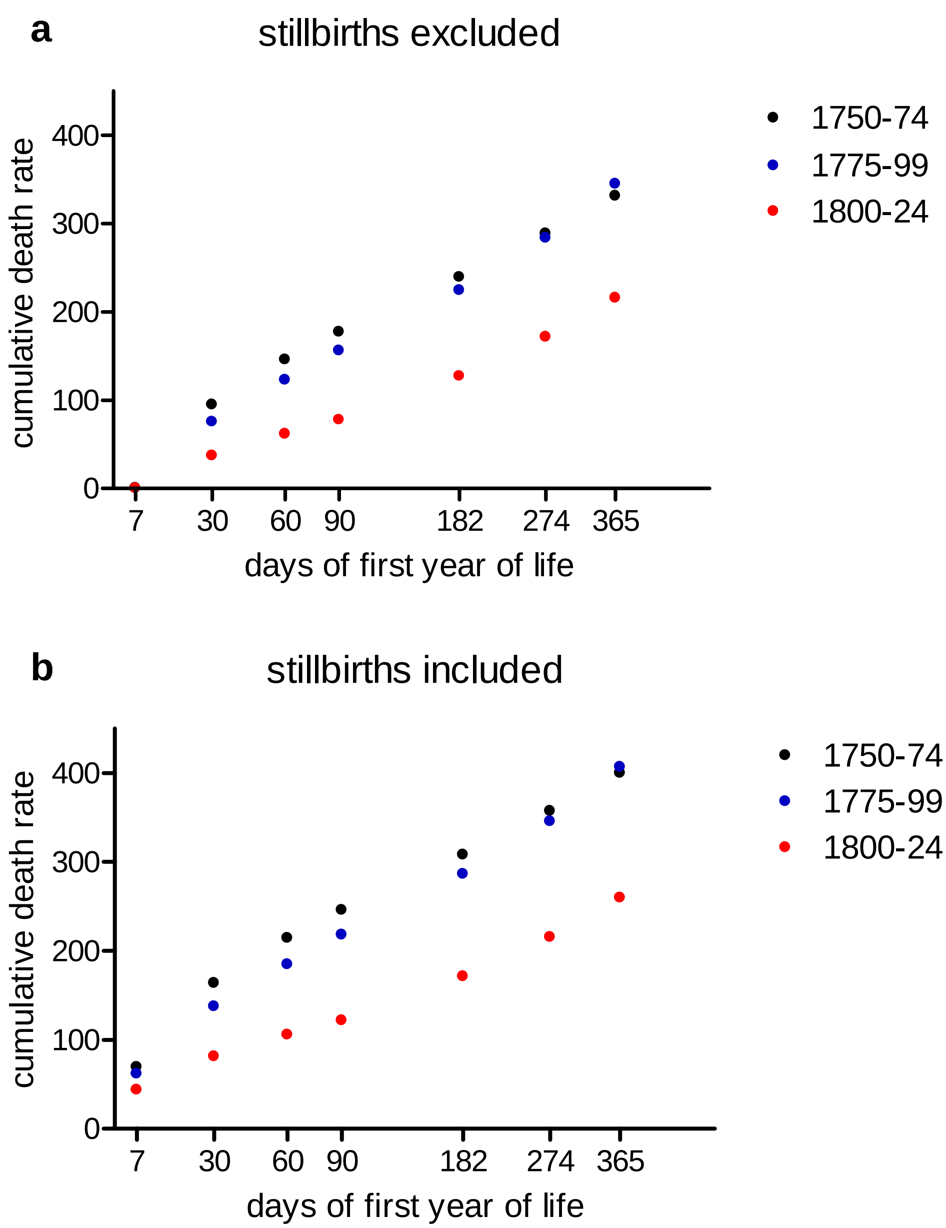

Figure 7. Bourgeois-Pichat analysis of infant mortality in St Martin in the Fields, by 25 year period. The x-axis is a $\log(x+1)^3$ transformation of days in the first year of life. The period 1800-1824 refers only to the period 1800-1811 and 1818-24, due to poor data quality in the years 1812-17.

All infant mortality series (including corrected series, and uncorrected with and without the inclusion of still births) showed the same pattern over the period 1750-1824. The

IMR rose in the mid-1760s and then returned to its earlier level during the 1780s-1790s, before declining dramatically in the period 1800-1824 (Fig. 8). This pattern differs from that of Landers' Bills of Mortality data, where the IMR declined from the 1740s (with some interruption in the 1770s), and was only ca. 250/1000 by 1800 (Landers, 1993: 170). Landers commented that this pattern was not consistent with that of the Quaker reconstitutions, and suggested that his use of correction factors may have exaggerated the extent of the decline in IMR before 1780 (Landers 1993: 192). The St Martin's IMRs were extremely high, the uncorrected series exceeding 450/1000 in the early 1770s, and averaging well over 300/1000 before 1800. These rates are much higher than those estimated for London as a whole and for the London Quakers by Landers, at least for the last quarter of the 18th century. Such high rates suggest that there was no significant under-recording of infant deaths, but does suggest the possibility that baptisms significantly under-counted births (although this is not consistent with the argument regarding the level of the crude birth rate, above). The rise in infant mortality in the late 1760s and early 1770s may reflect some undercounting of infant deaths in the previous period; this is certainly evident for the period of the General Reception at the London Foundling hospital (1756-60), when the hospital dramatically increased its intake of infants, whose deaths would have been recorded outside the parish. However the rise in the IMR also corresponds to a period of change in the age pattern and frequency of smallpox epidemics in London, that resulted in a doubling of the infant smallpox rate in St Martin's, and so is most likely to represent a genuine worsening of IMR. Moreover, the pattern of infant mortality rates is mirrored to some extent in burials at other ages, for the period 1760-1780, which could indicate either a general defect in the burial records, or a general worsening of mortality across age groups (Fig. 4). The only convincing evidence of secular decline in infant mortality in St Martin's is in the period 1800-24, and the proportionate decline from 1800 to 1824 is much larger when the stillbirths are included (because the stillbirth rate halved in this period) – the IMR almost halved in a 25 year period, if stillbirths are included. Such a rapid decline is rather incredible, but does coincide with the virtual disappearance of smallpox in St Martin's. Smallpox burials represented around 6.5% of infant burials in the preceding period, and this is likely to underestimate the impact of smallpox, since smallpox symptoms were often atypical in infants. A decline in infant smallpox would not account for the drop in the recorded stillbirth rate, but could account to some extent for the decline seen in all IMR series, and in the exogenous mortality rate (see below).

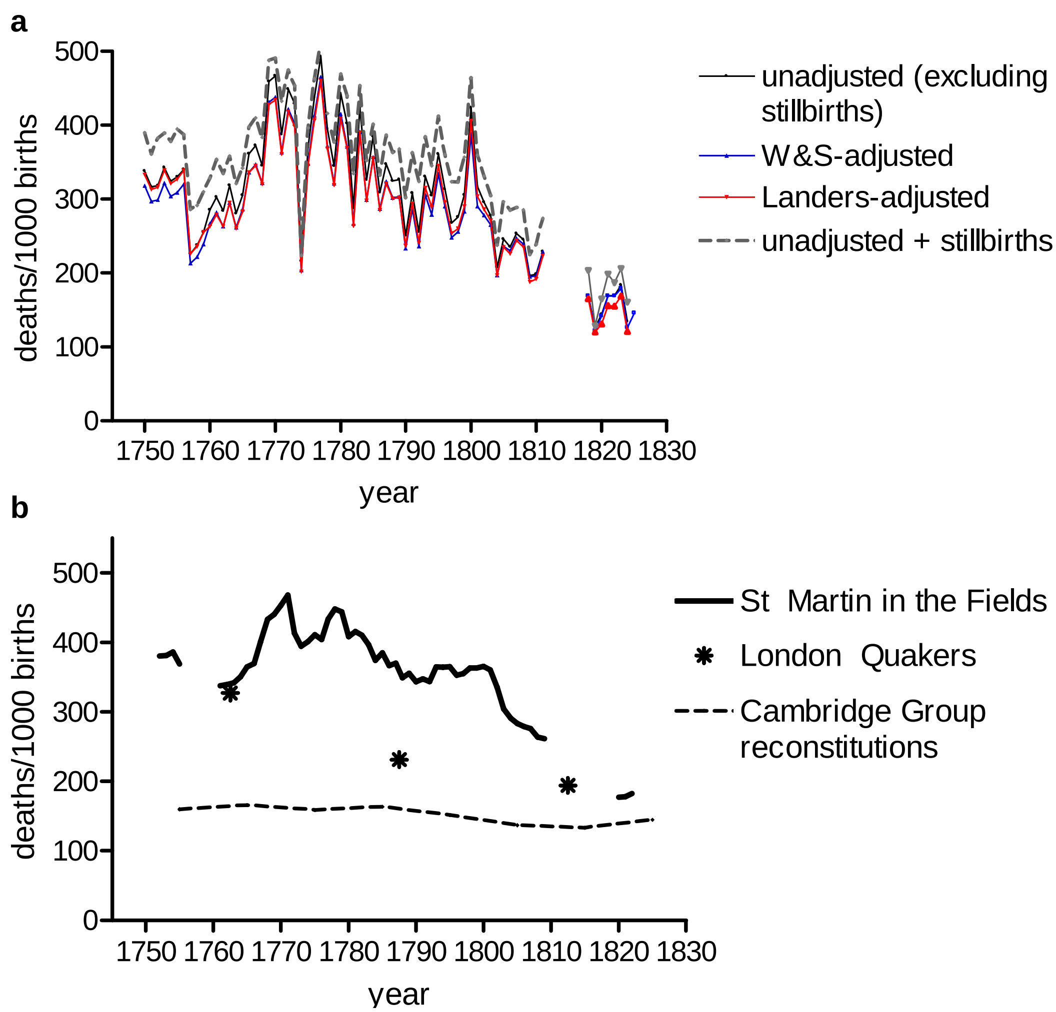

Figure 8. Estimates of infant mortality rates for St Martin in the Fields, 1750-1824 (1812-17 excluded due to poor data quality). In panel a, rates were calculated using burials for ages under one year, and baptisms in the same year, and where correction factors were applied to burials, the corresponding factors were applied to baptisms. Where stillbirths were included in infant deaths ('unadjusted + stillbirths') the stillbirths were also added to the baptisms. 'W&S' refers to correction factors applied by Wrigley & Schofield to national totals (1989, table A4.1: 537-552), 'Landers' to the correction factors applied to the London Bills of Mortality data by Landers (1993, table 5.3: 166). Panel b shows the five year moving average of the St Martin's IMR calculated from uncorrected infant burials and baptisms, including stillbirths (the periods of the General Reception at the Foundling hospital, 1756-60, and of poor data quality, 1812-17, have been excluded). Also shown are Landers' estimates of the IMR of London Quakers (by quarter century, plotted at the midpoint of each period) (Landers, 1993: table 4.3: 136) and the decadal IMRs of the Cambridge Group reconstitution populations (legitimate births only: Wrigley et al. 1997, table 6.6: 239).

Infant mortality can be decomposed into two broad categories. Endogenous mortality is described as that component of infant mortality attributable to *in utero* conditions (such as prematurity), heritable disorders and conditions of birth, and is concentrated in the early weeks of life. Exogenous mortality comprises deaths from other causes, and is largely composed of infectious disease mortality in infants. Wrigley et al. (1997) found that the levels of endogenous mortality in their reconstitution populations fell from around 60/1000 births in the mid-eighteenth century to around 40/1000 in the first quarter of the nineteenth, and that by the nineteenth century there was little variation in endogenous mortality between urban and rural, healthy and unhealthy locations, despite large and persistent differences in total infant mortality. Biometric analysis of the St Martin's infant deaths indicated that endogenous mortality declined over the whole period 1750-1824, from 120/1000 to 29/1000, a rate of decline double that of the reconstitution populations in the mid-18th century, but converging to the same level by the early 19th century (Fig. 9). Both the national and St Martin's rates of endogenous mortality were rather higher than the rates calculated by Landers for the London Quaker reconstitution populations particularly in the eighteenth century. The Quaker rates seem anomalously low but perhaps indicate some peculiarity of Quaker practices that might help explain the wider decline of endogenous infant mortality. By contrast, exogenous mortality appears to have risen in the second half of the eighteenth century in St Martin's, before returning to the levels of the 1750s in the first quarter of the nineteenth century. This is distinct from the pattern observed by Wrigley et al. in their reconstitution parishes, where exogenous mortality was fairly stable or declined in the late eighteenth century. Exogenous mortality also declined in the London Quaker reconstitution population, suggesting that the main difference in the IMRs between the Quaker and St Martin's populations in the later eighteenth century was in the levels of infectious disease mortality. Thus it appears that the main cause of the fluctuations and excessively high IMR in St Martin's was fluctuations in infectious disease mortality, against a background of improving neonatal mortality.

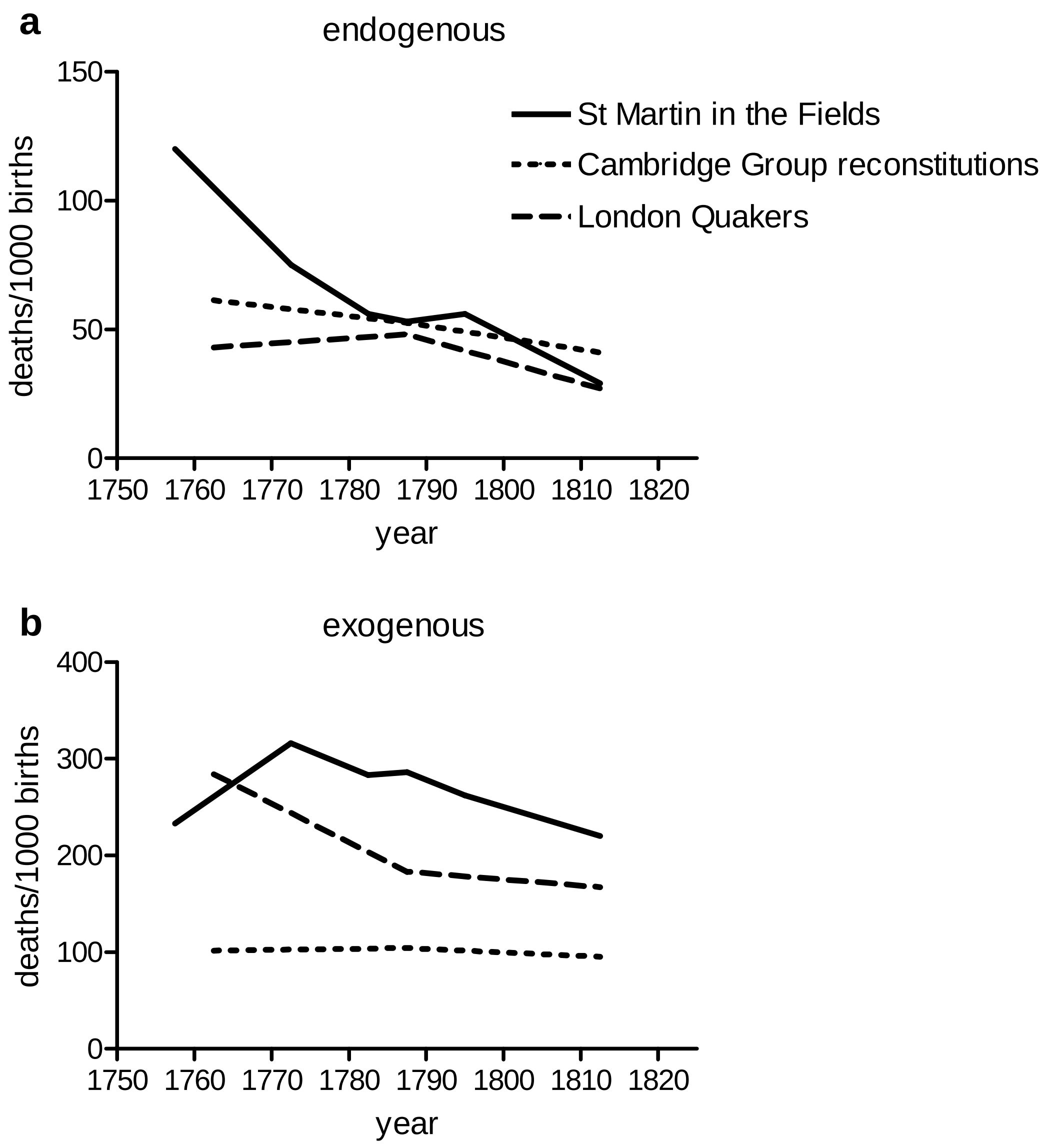

Figure 9. Endogenous and exogenous infant mortality rates. St Martin's rates were calculated by biometric analysis of uncorrected infant burials and baptisms (stillbirths included in both series). The last period excludes 1812-1817. Endogenous mortality was estimated from the y-intercepts of linear regressions fitted to cumulative mortality from 1 month of age. In all cases linear regression produced a very good fit to the data (r^2>0.99). Exogenous mortality was calculated as the difference between the total IMR and the endogenous component.

Maternal mortality

The decline in endogenous infant mortality in the Cambridge Group reconstitution populations was paralleled by a decline in the maternal mortality rate, and Wrigley et al. (1997) suggested that both trends reflected an improvement in maternal health. Young adult mortality declined over the 18th century in the reconstitution populations, and this may have been partly a consequence of the process of endemicisation of various infectious diseases at the national level, resulting in a progressive reduction in the average age at infection. However most of the improvement in young adult mortality and maternal mortality occurred in the first half of the eighteenth century, whereas the improvement in endogenous mortality accelerated in second half of the century (Wrigley et al. 1997, Tables 6.5 and 6.19: 236, 290). Maternal mortality in the St Martin's population was estimated using burials with the cause 'Childbed', and two estimates of the numbers of births (Fig. 10). The pattern of maternal mortality was similar to that of the total IMR, except that there was little evidence of a decline in maternal mortality before the 1820s (and the latter may reflect the poor recording of causes in that period). There was no evidence of a decline in maternal mortality comparable to that of endogenous infant mortality, whether uncorrected baptisms or baptisms corrected for a decline in recording were used to calculate the rate. Except for the period of excessive mortality in the 1760s and 1770s, the level of maternal mortality was generally similar to that calculated for London, and was comparable to that of the Cambridge Group reconstitution parishes (Wrigley et al. 1997). Therefore maternal mortality in St Martin's was not unusually high (although the rates for St Martin's will be underestimated compared with the measure used in the reconstitution populations, because 'Childbed' would have excluded deaths in pregnancy as well as those occurring with some delay after childbirth but attributable to pregnancy or childbirth). Childbed deaths were a smaller proportion of pauper than non-pauper burials amongst young adult females, suggesting that fertility was lower amongst paupers, and this is consistent with a concentration of unmarried migrant servant burials amongst the pauper burials (see below). It is possible to calculate a maternal mortality rate for workhouse burials, because the number of workhouse baptisms is known, but the number of burials was very small, and no maternal deaths were recorded after 1790, although the number of workhouse baptisms remained fairly stable. The comparison suggests that most of the excess maternal mortality in the late 1760s and early 1770s occurred in the workhouse (Table 1), however the small numbers involved make it unwise to draw any conclusions regarding relative rates of maternal mortality amongst paupers and non-paupers. A larger sample would be needed to conclude that maternal mortality was worst amongst paupers (perhaps including migrant women), and improved in this group alone before 1800.

The maternal mortality rate was the only mortality rate that could be calculated for adults, and its stability in St Martin's over the second half of the 18th century did not suggest any improvement in young adult mortality that affected maternal survival rates. This is consistent with the patterns of maternal and young adult mortality in the Cambridge Group reconstitution populations, where both maternal and young adult mortality rates stagnated in the later 18th century. If maternal mortality did indeed reflect young adult health more generally, then these data suggest that young adult health in St Martin's did not improve much in the period 1750-1800, but improved markedly afterwards, as indicated by the ASMRs in Figure 6 and by the late improvement in the maternal mortality rate. Conversely, the maternal mortality rates are consistent with a transient rise in young adult mortality in the 1770s, but no overall worsening.

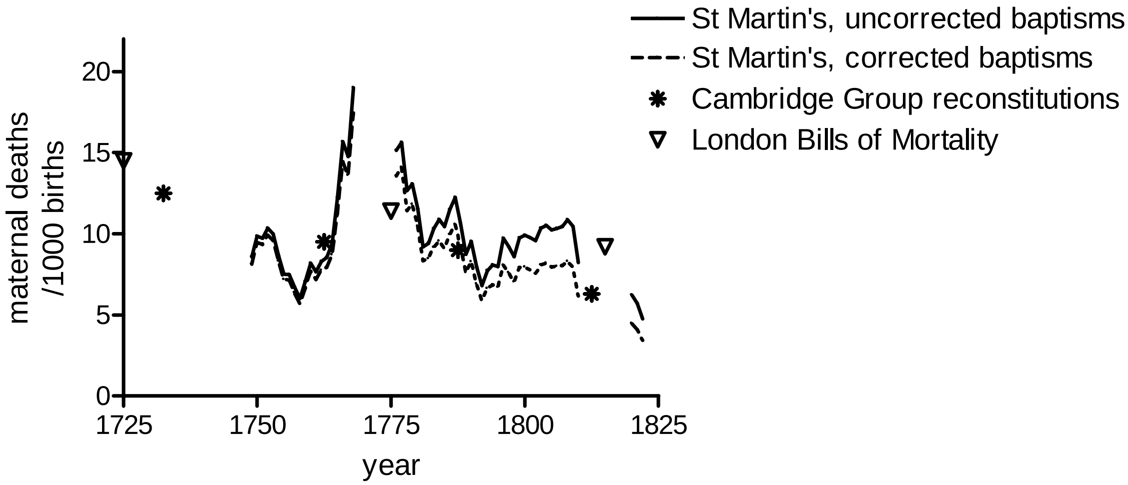

Figure 10. Maternal mortality rates, calculated for St Martin's using uncorrected baptisms including stillbirths, or baptism totals inflated using correction figures from Wrigley & Schofield (1989, table A4.1: 537-552). The London Bills rates were calculated using 'Childbed' burials (Wrigley et al. 1997: 308), and the Cambridge Group reconstitution rates using deaths within 60 days of child birth, corrected for background mortality and inflated to include stillbirths and deaths in pregnancy (Wrigley et al. 1989 table 6.29: 313).

Period	workhouse	Non-workhouse
1750-68	53.4 (618)	8.5 (14210)
1775-99	11.5 (1653)	10.6 (17933)
1800-11, 1818-24	0 (960)	8.9 (14039)

Table 1. Maternal mortality in St Martin in the Fields, by period and location. Rates are per 1000 births (including stillbirths); numbers of baptisms at risk are given in brackets. The period 1769-74 was excluded due to poor recording of cause of death in those years (see text).

If young adult mortality were relatively stable in the period 1750-1800, then this leaves the question of the cause of the decline in the endogenous infant mortality rate at the national level, and its particularly rapid fall in St Martin's. Endogenous infant mortality rates were much higher in this period than in any modern populations, but were probably similar to other contemporary European populations (Wrigley et al. 1997: 315-16), making it unlikely that particular early breastfeeding or obstetric practices were responsible (although the evidence of low endogenous mortality from the London Quakers is suggestive).

4. Migrants in the St Martin's population

The St Martin's burial data do not explicitly distinguish migrants from native born city residents. However the burial data do include cost of burial, as well as address of the deceased, and from these it appears that migrant burials were concentrated amongst pauper burials, at least in the case of female migrants. The evidence for this comes from the age pattern of pauper burials, and the unbalanced sex ratio of burials. The proportion of burials that were pauper (free burial) rose with age in the early teens, and female burials contained a consistently higher proportion of paupers than male burials at all older ages (except in the teen ages in the 1800-24 data) (Fig. 11). Note also the decline in the proportion of pauper deaths over the period, at all ages, suggesting either a progressive reduction in the proportion of paupers in the parish, or a significant improvement in their health relative to other groups. Figure 11 also shows the sex ratio (male:female) of burials by age: in each period the sex ratio dropped below one in the teen years, and sex ratios were very low in early adulthood. The female excess of burials in these age groups was in part, and probably mainly, due to the much larger number of females relative to males in the population in these ages (rather than much higher female death rates), due to high levels of female immigration. The rise in the sex ratio in middle age probably reflects high male mortality relative to females in this age range, as well as emigration of older female migrants (indicated by the reduction in the sex difference at ages above 40 in the London populations in Fig. 1). The persistence of female migrants in the population was possibly a feature of the earlier period, as the sex ratios of burials are below parity for almost all adult ages, indicating a persistent surplus of females. The decline in the sex ratio of burials at oldest ages reflects both this tendency of female migrants to remain in St Martin's, and the higher death rates of males at earlier ages. Thus the influx of female migrants at adolescent and young adult ages both skewed the sex ratio of burials and coincided with a sudden increase in the proportion of female burials that were pauper (relative to younger ages and to males), suggesting that those migrants who died may have been disproportionately likely to have a pauper burial.

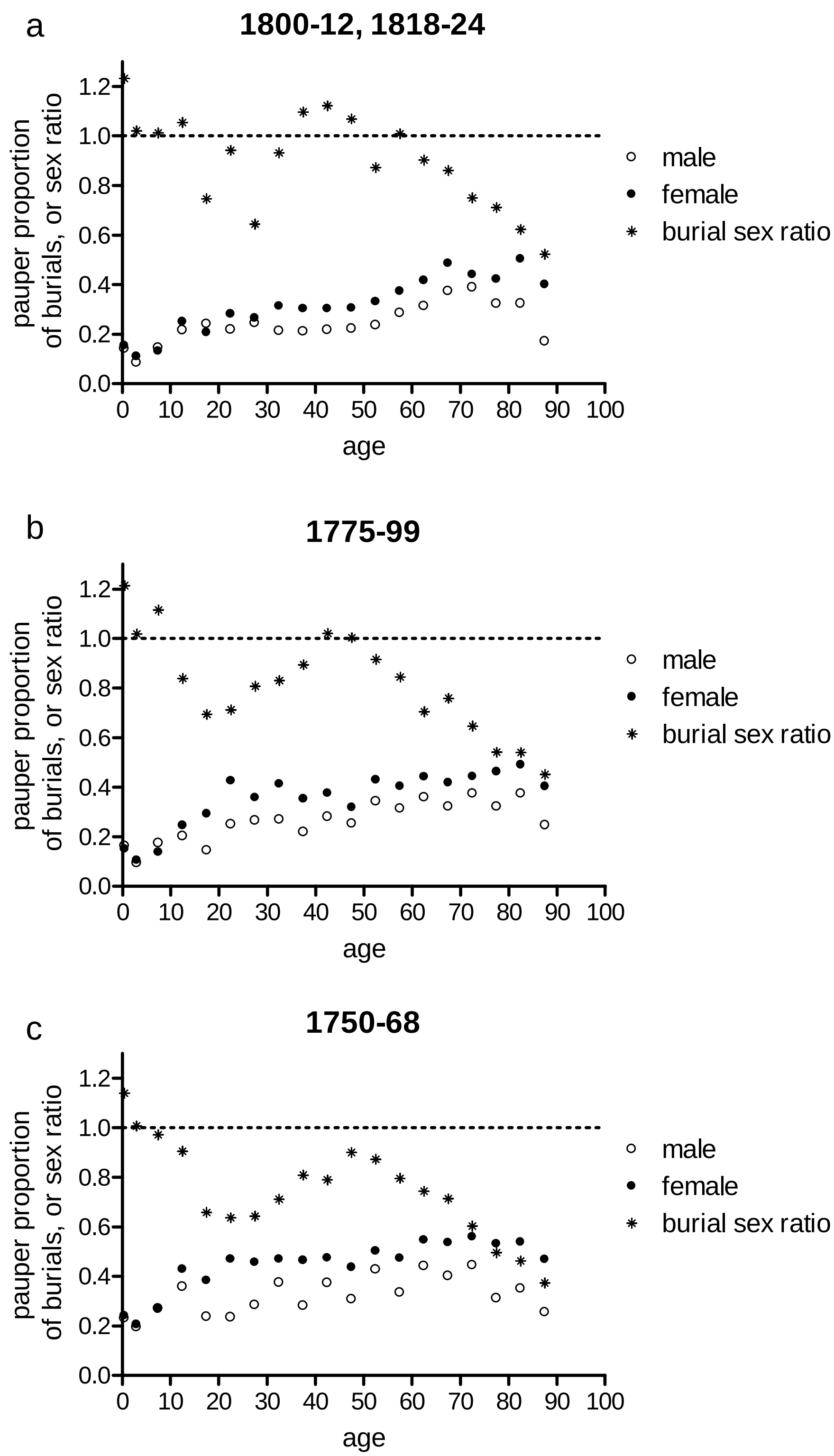

Figure 11. Sex ratio of burials and proportion of burials by sex that were pauper, by age and period. Burials of unknown age have not been redistributed, but constituted less than 5 % of burials in the years included in analysis, and appear from cause of death analysis relatively unbiased with respect to sex, age and pauperism.

As the rise in the proportion of pauper burials in adolescence suggests, the female excess of burials in the young adult ages was concentrated mainly in the pauper category (Fig. 12). In the earlier period (1750-68) 70% of pauper burials at ages 15-39 were female, but the sex ratio was much more equal at higher burial costs (Fig. 12a). This tendency was more pronounced in the later periods (1775-99, 1800-24), when the sex ratio was almost parity for all non-pauper burials. Note that the cost categories in Figure 12a are not evenly distributed across burials, as shown in Figure 12b. Free burials constituted the largest cost category of burials, accounting for nearly 40% of burials in the first period (1750-68). In all periods, the sex ratio was below parity for the cheaper 50% of burials, but roughly parity for the more expensive half of burials. Consistent with this, mean non-pauper burials costs did not differ significantly between the sexes at any ages (calculated as geometric means: data not shown). These data suggest that the rise in the number of women in the population in early adulthood (through migration) produced a corresponding rise in the number of pauper burials, with little effect on the numbers at risk in higher burial cost categories. The most plausible scenario is that female immigrants were most likely to be poor and accorded pauper burials at death. One (less plausible) alternative explanation is that the influx of female migrants displaced the local female population in the economic heirarchy, so that the normal sex ratios at higher burial costs were composed of mainly native-born men and immigrant females, with local-born females making up the female excess of pauper burials. Another possible explanation is that the excess of female burials relative to male in early adulthood was a function of higher female mortality rates, and this excess mortality occurred mainly amongst pauper women (in the first period the sex ratio was also female-skewed at higher burial costs, also suggestive of some excess female mortality that was common throughout the economic heirarchy). However this explanation is inconsistent with the low sex ratios of burials at all adult ages, which indicate a female excess in the population at risk (since, assuming no recent changes in sex ratios of mortality, female excess mortality at younger ages should raise the sex ratio of the population at risk at older ages, resulting in a more equal sex ratio of older burials). Note that the first explanation does not mean that most pauper burials were immigrant, but that most immigrant burials were pauper.

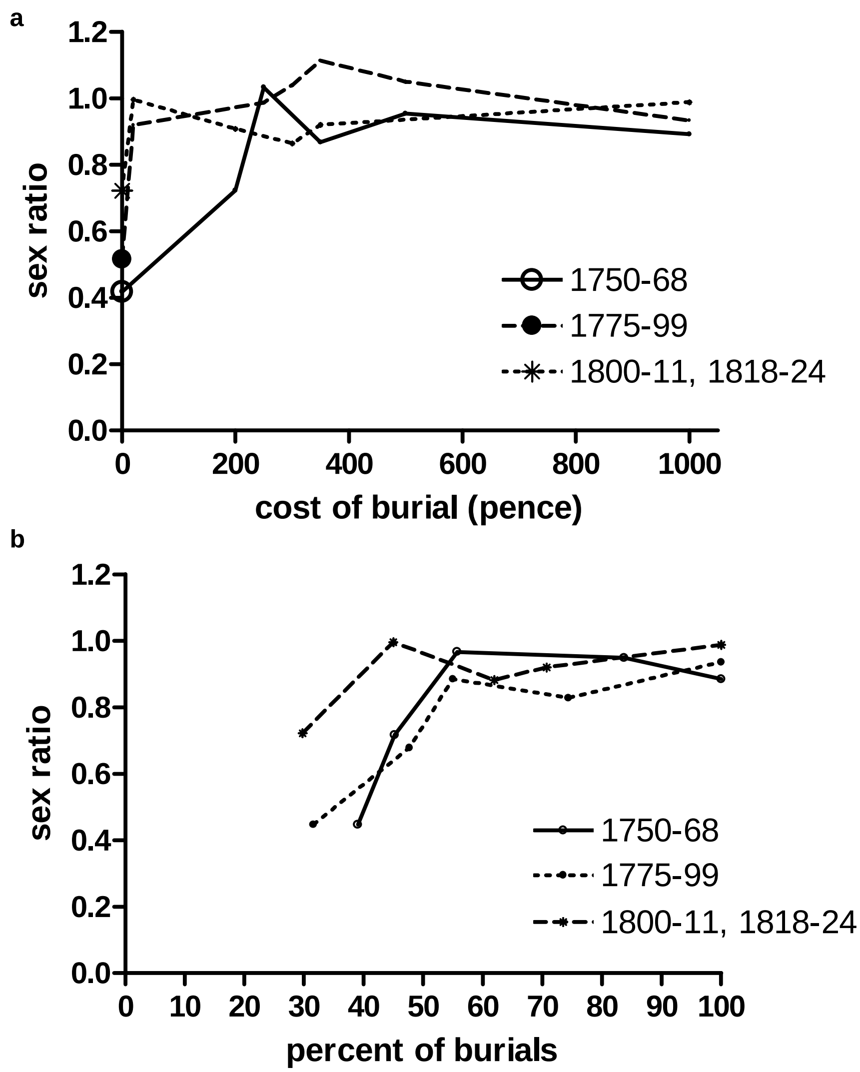

Figure 12. Sex ratios of burials for ages 15-39, by cost (panel a) and by percentile of burials in a given cost category (panel b). The first data point for each series represents pauper (free) burials. Panel b shows the sex ratio for percentile bands of burials by rising cost, plotted at the upper boundary of each percentile band. For example, in 1750-68, 39% of burials of adults aged 15-39 were pauper, with a sex ratio of 0.45. The next 6% of burials cost less than 160p, with a sex ratio of 0.72.

One caveat to this argument, that migrant female burials were predominantly pauper, is the lack of difference in the sex ratio of pauper burials in and outside the workhouse (data not shown). The sextons' books give address of the deceased, and most deaths that were recorded as taking place in the workhouse were pauper burials. It might be expected that migrants would not necessarily gain settlement in the parish and so would be less likely to die in the workhouse than the native-born poor. However there appears to be a similar preponderance of females amongst pauper burials within and without the workhouse. Migrants could qualify for settlement after a year of service in a parish, and it is possible that many or most female migrants did. Moreover it may be the case that young adult migrants were more likely to resort to the workhouse than their native-born peers, due to lack of other forms of support. The workhouse data certainly indicate that the workhouse was used as a hospital (most deaths occurring within a week of admission), and ill migrants might have been particularly prone to this practice[5].

The pattern of burials by sex and cost suggests that at least female young adult migrants were likely to receive pauper burials. Unfortunately the evidence regarding sex ratios does not yield information about male migrants, except to the extent that male migrants can be assumed to have been as poor as female migrants, which is probably not justified. If the argument regarding the association of migrants with especially pauper burials is correct, then it provides a basis for attempting to distinguish those causes of death that may have discriminated between migrants and native-born young adults. This exercise is demonstrated below with respect to smallpox deaths, but could be extended to the other main causes of death in young adults.

5. Causes of death by sex and cost of burial in young adults, 1750-1799.

Causes of death were recorded with varying degrees of enthusiasm in the sextons' books. Causes in the period 1769-74 were particularly poorly recorded and have been excluded. After 1800 causes were often omitted and the proportion of missing causes was higher amongst pauper burials, therefore only the periods 1750-1768 and 1775-99 are considered in the following analysis. In these periods the proportions of burials without recorded causes varied between 0-20%, but there was little bias by sex, age or pauper status (although there was a bias within pauper burials, with workhouse pauper burials more likely to include a cause). Age at burial was poorly recorded in the period 1750-68 (15.6% of burials) but was rarely omitted in the later period. The sex ratio, proportion pauper burials and distribution of causes in burials with no age given were similar to these values for the whole burial sample, suggesting, perhaps surprisingly, that there was relatively little bias in risk of age omission (data not shown). Sex of burials was omitted in approximately 5% of burials, but most of these were infant burials, and there was no bias in omission of sex of burial by pauper status.

'Fever', 'Consumption' and 'Smallpox' accounted for 72% of young adult burials over the period 1750-1799 in the sextons' books of St Martin's (excluding 1769-74). These were also the causes most likely to show differences by migrant status. Several methods were used to test whether migrants were at higher risk of a particular cause of death. Firstly, a lower than average sex ratio for a particular cause amongst young adults could suggest that migrants were particularly subject to that cause of death. The sex ratio of burials (male:female) was low for young adult burials (ages 15-39), and this primarily reflected the sex imbalance in the population. Since the excess of young adult females was a consequence of high female immigration rates into St Martin's, the sex ratio amongst immigrants should have been higher than amongst native-born young adults, and therefore the sex ratio of burials should be lower than average for any disease that primarily affected immigrants. Some diseases may however have been sex-selective, without distinguishing migrants. This possibility might be distinguished from a migrant

---

[5] In addition to the sextons' books the Wellcome project also generated a dataset of the St Martin's workhouse records, comprising nominal level records of dates of admissions and discharges by age, sex, and reason for discharge

effect by two means; firstly, consideration of the sex ratio of cause-specific burials at other ages, where migrants were less predominant in the population, and secondly by comparison of the sex ratios in the pauper and non-pauper burials. Secondly if, as argued above, migrants were more likely to receive pauper burials, then any disease that predominantly affected migrants should have a lower mean cost of burial and higher proportion of pauper burials than all-cause burials. Burial costs were not normally distributed, having a high proportion of pauper burials ('left truncation') and a long tail of high cost burials, and therefore average costs provided a poor means for comparison. However when free burials were excluded then logging the remaining non-zero cost values produced fairly normal distributions, and so means and significance tests were calculated using logged distributions. Pauper burials were analysed as simple proportions of total burials by age and sex; the relative proportion of paupers usually coincided with the mean non-pauper cost by cause, relative to all-cause burials.

Smallpox

Smallpox is considered to be a classic example of the type of disease to which McNeill's hypothesis applies: it was transmitted person to person, was highly contagious and lethal, and conferred lifelong immunity on survivors. In a population in which smallpox was endemic, smallpox mortality rates should show an exponential decline with age from age one (infants were partially protected by maternal antibodies acquired *in utero* from immune mothers). Smallpox is considered to have been endemic in London by the eighteenth century, but the London Bills show a relatively large number of deaths from smallpox at ages over ten, which Landers attributed to the presence of young adult immigrants who lacked immunity. The St Martin's burials show a similar excess of young adult smallpox burials, and this is unlikely simply to reflect the excess of individuals at risk in these age groups (Fig. 13). Smallpox accounted for 7.9% of young adult burials in the period 1750-1768, but only 2.0% in 1775-1799. The proportion of smallpox burials that was adult dropped dramatically after the early 1770s, apparently in response to an increase in the frequency of epidemics (Schwarz et al., in prep). Smallpox mortality at all ages declined dramatically after 1800.

It seems unlikely in the case of St Martin's that the excess of adult smallpox deaths can be attributed simply to the high numbers of immigrants. Firstly, the sex ratio of smallpox deaths in the first period (when smallpox was still a major cause of death in young adults) was above one for all age groups (Table 2). Thus young adult smallpox burials were more likely to be male than female, despite the excess of females in this age group (ages 15-39). Male smallpox burials slightly outnumbered female even amongst paupers, where the female excess of all-cause burials was highest (data not shown). The smallpox sex ratio was only significantly different from that of other causes for young adults, and only in the period before 1775. Secondly, smallpox burials were less likely to be pauper than all-cause burials, and this difference was greatest in the case of young adult burials in the period 1750-68 (Table 2). When paupers were excluded from burial cost means, then the average cost of burial did not differ significantly between smallpox and all-cause burials. Thus young adults dying of smallpox appear to have been richer on average (that is, less likely to be paupers), and more likely to be male, than those dying from other causes. While smallpox victims were therefore unlikely to be drawn mainly from the dominant group of migrants in St Martin's (female domestic servants), the unexpectedly high proportion of smallpox deaths in young adults does suggest that victims were not native Londoners. One possibility is that adult smallpox victims included an unusually high number of high status young adults, coming to St Martin's for the season from relatively remote areas. Seasonality of burials may help to test this possibility. Alternatively, a minority of more long-term migrants may have been the principal victims, such as families or apprentices coming from remote areas, with more normal sex ratios and less risk of pauper burial. These explanations would not account for the correlation between smallpox mortality and wheat prices found using two different methods by Landers and Galloway. This correlation led both authors to argue that susceptible young adult migrants were more likely to come to London in years of poor harvests, and to fall victim to smallpox. Further analysis of the age, sex, and cost of smallpox burials in St Martin's with respect to wheat price data may help to elucidate whether young adults were indeed at higher risk in years of high prices. However the St Martin's data suggest that young adult labour immigrants were not generally at higher risk of smallpox than the rest of the population.

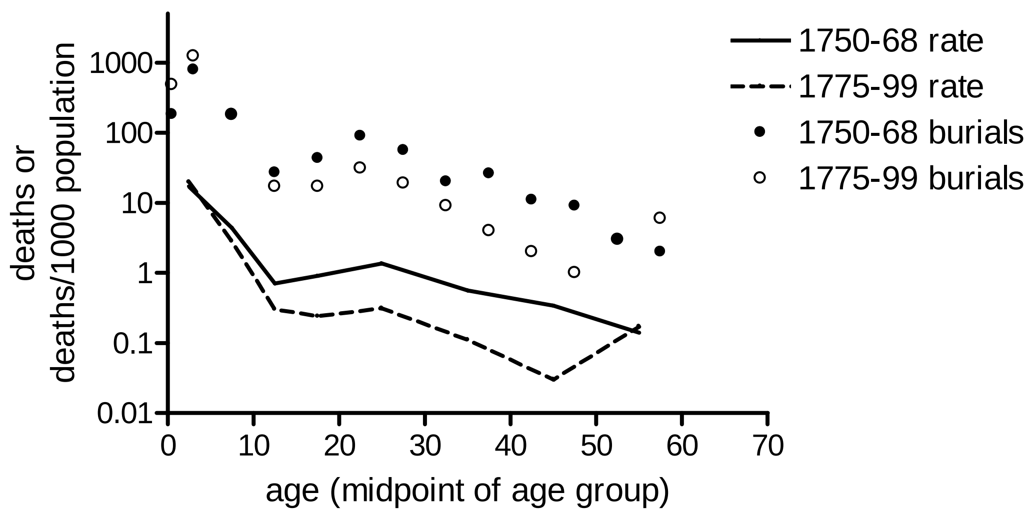

Figure 13. Smallpox burials and estimated age-specific death rates, sexes combined. Death rates were estimated using the age distribution of the Westminster population in 1821 and assuming a population size for each period based on an average CBR of 30/1000.

		Age groups			
	Period	0-14	15-39	40+	No age given
Sex ratios					
All causes (excluding 'Childbed')	1750-69	1.077 (9191)	0.728 (2792)	0.712 (4849)	0.924 (3104)
	1775-99	1.111 (13098)	0.876 (3893)	0.800 (7909)	1.181 (554)
Smallpox	1750-69	1.071 (1189)	**1.026**** (235)	1.27 (34)	1.01 (153)
	1775-99	1.080 (1918)	0.818 (80)	0.667 (15)	2.333 (10)
Mean cost of non-pauper burials					
All causes	1750-69	102 (101-103)	365 (357-373)	411 (401-420)	154 (147-161)
	1775-99				
Smallpox	1750-69	111 (108-114)	353 (334-373)	429 (314-588)	141 (125-159)
	1775-99				
Pauper percentage of burials					
All causes	1750-69	26.6	41.1	47.1	38.7
	1775-99	14.2	31.6	37.0	22.8
Smallpox	1750-69	18.9	23.8	35.3	21.2
	1775-99	9.2	28.6	25.0	40.0

Table 2. Sex ratios (male:female) and burial costs of selected causes of death, by age and period (number of burials in brackets). *indicates that the difference in the sex ratio between the named cause and other causes was significant at the 5% level ($P \leq 0.05$), ** at 1% ($P \leq 0.01$). Bold entries are those with a significantly higher sex ratio than other causes. 'Childbed' deaths were excluded from the all-cause sex ratio and from statistical calculations. Mean costs of non-pauper burials were calculated as geometric means and 95% confidence intervals (in brackets).

Fever and Consumption.

'Fever' deaths probably included deaths from a range of acute infectious diseases, including some meeting McNeill's criteria. Landers found 'fever' to be particularly associated with young adult mortality in the London Bills. Galloway (1985) found a correlation between 'fever' burials and wheat prices, and suggested that this category included acute infectious diseases to which migrants were particularly susceptible. 'Consumption' probably included deaths from pneumonia as well as respiratory tuberculosis in this period (Landers & Mouzas, 1988). Neither pneumonia nor tuberculosis fits McNeill's model, since neither confers immunity on survivors. Consumption accounted for around 40% of young adult burials in St Martin's the late 18th and early 19th centuries, despite the large proportion of burials with no recorded cause in the latter period, and this is consistent with the preponderance of respiratory tuberculosis mortality in young adults later in the 19th century. By the 1850s, respiratory tuberculosis accounted for 50% of young adult deaths, and was more lethal to women than men in this age group. However in St Martin's consumption did not show the mortality peak in early adulthood typical of respiratory tuberculosis in the later 19th century, possibly due to the inclusion of other respiratory causes, which usually resemble all-cause mortality in their age-specific mortality patterns, or because young adults in this population were not particularly prone to tuberculosis.

Fever and consumption deaths were considered together, because they formed such a large proportion of young adult deaths that they tended to move in reciprocal fashion, as proportions of burials. There was a large difference between the two periods 1750-68 and 1775-99. In the third quarter of the 18th century the proportion of burials that were attributed to consumption was similar in paupers and non-paupers (Fig. 14a,b). There was a slightly higher proportion of fever burials amongst pauper burials than non-pauper burials, and this was a feature of young adult ages only. In the last quarter of the century proportions of burials due to fever and consumption changed little amongst pauper burials in young adulthood (Fig. 14c,d). However there was a dramatic change in the patterns of burials in non-pauper adults. The proportion of fever deaths fell, and the proportion due to consumption rose, and this was most pronounced at young adult ages. In fact the age distribution of consumption burials appeared to change, to one much closer to the pattern of consumption deaths (by proportion of each age class) in the nineteenth century. That is, consumption became the major cause of death in the range 20-59, but was much less important at older ages. Amongst paupers consumption assumed a very odd distribution, accounting for around 30% of young adult burials, but over 50% of burials in the age range 40-59. While this was apparently a consequence of the reciprocal behaviour of fever and consumption (since a high proportion of one cause necessarily lowered the proportion that the other cause assumed), it should be noted that the proportions of fever and consumption burials hardly altered in young adult paupers between the first and second periods, and so the main change was in the older adult ages, where consumption became the dominant cause of death at ages 40-59.

As a consequence of these changes in the distribution by cause of non-pauper burials, fever burials in the period 1775-99 were dominated by pauper burials, to a much greater extent than earlier, and consumption burials were correspondingly less likely to be pauper (Fig. 15b). However in this period the association of fever with paupers was not confined to young adulthood, but was apparent at all ages (expressed as relative risk of pauper burial in fever burials compared with all-cause burials, Fig. 15b). Figures 14 and 15 show only female burial proportions, but similar trends were observed in males (although the absolute proportions of paupers were lower amongst male burials). When sex ratios were calculated by pauper status, the sex ratios of fever and consumption burials did not differ from those of all cause burials (data not shown).

These results suggest superficially that paupers were at higher risk than non-paupers of fever, and this difference in susceptibility increased in the last quarter of the 18th century. However, except in the case of smallpox, where the sex ratio of burials was unambiguous, it was not possible to determine whether a cause caused higher or lower mortality amongst paupers than amongst those able to pay for burial, because the size of the subpopulation of paupers was not known. For example, if paupers were present in the population in the same proportion as their total burials, then this would imply a higher rate of fever mortality amongst paupers than other groups. However it is also possible that the rate of fever mortality amongst paupers was the same or lower than that of non-paupers, but that consumption mortality was even lower, thus inflating fever as a proportion of pauper burials. Paupers would then have dominated fever burials only because they formed a large proportion of the population. This interpretation does not seem tenable for the period 1775-99, because the proportion of fever burials that was pauper reached 70% for some ages, which would imply that paupers constituted at least 70% of the population in these age groups. This would also imply that both all-cause and consumption mortality was much lower amongst paupers than non-paupers, because the proportions of all-cause and consumption burials that were pauper were very low compared with fever. Thus it does seem that in the last quarter of the 18th century fever death rates were probably higher amongst paupers than non-paupers, and that this difference persisted at all ages. This could suggest some new distinction in susceptibility to disease by class, or some change in diagnosis of disease by class. Comparison of the seasonality of fever and consumption burials may help to decide this. In any case, a comparison of fever and consumption mortality does not provide much support for a specific vulnerability of newly arrived migrants to infectious diseases described as fevers. Such vulnerability would be expected to be more obvious in the earlier period (when the process of endemicisation would have been less complete) and more clearly confined to young adults. With respect to consumption, paupers formed a smaller proportion of consumption burials compared with other causes of burials, and this effect was confined to the later period and young adults (Fig. 15b). This could indicate that consumption mortality was lower amongst young adult migrants compared with non-paupers in this period, or that consumption rates were the same or higher in migrants compared with non-paupers, but that other causes of mortality were even higher. Thus it is only possible to say that this pattern is consistent with the possibility that young adult migrants were less likely than the rest of the population to suffer chronic diseases, and that this characteristic became evident in the last quarter of the 19th century.

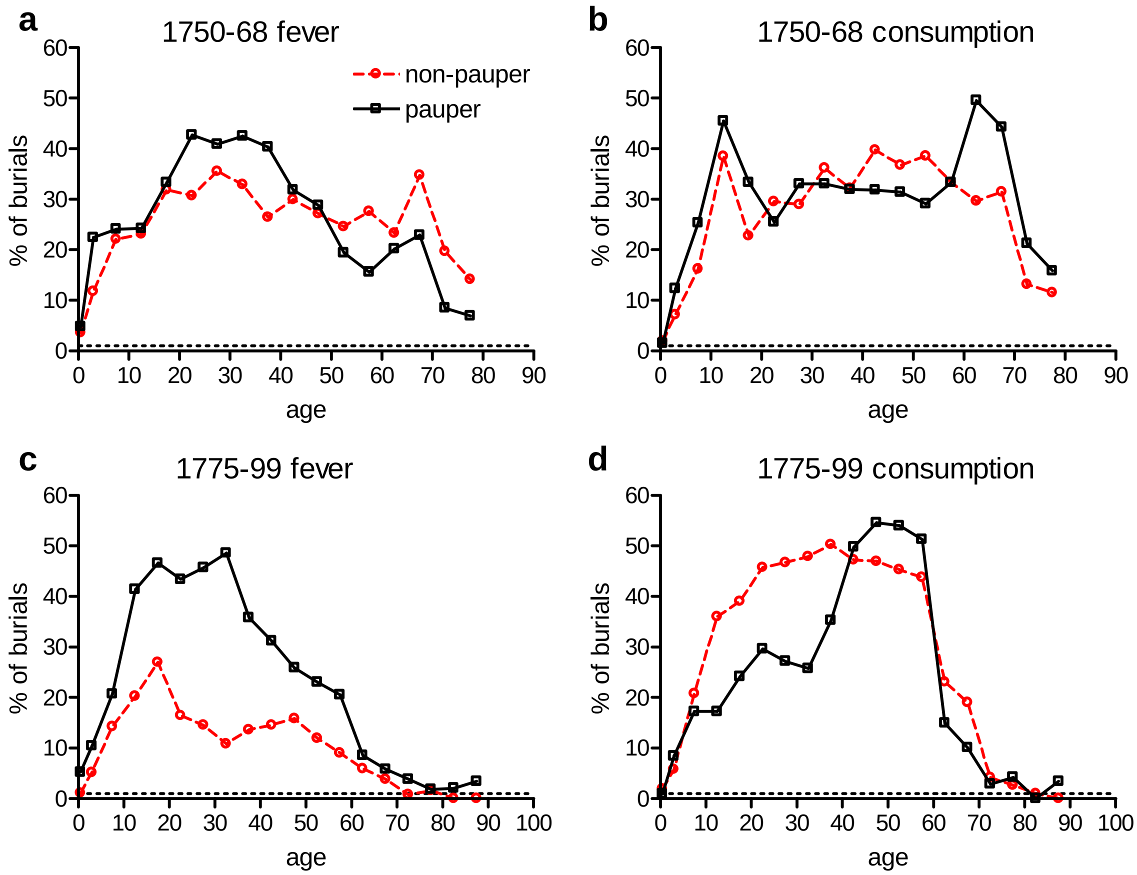

Figure 14. Proportions of female burials that were attributed to fever or consumption, by age and period.

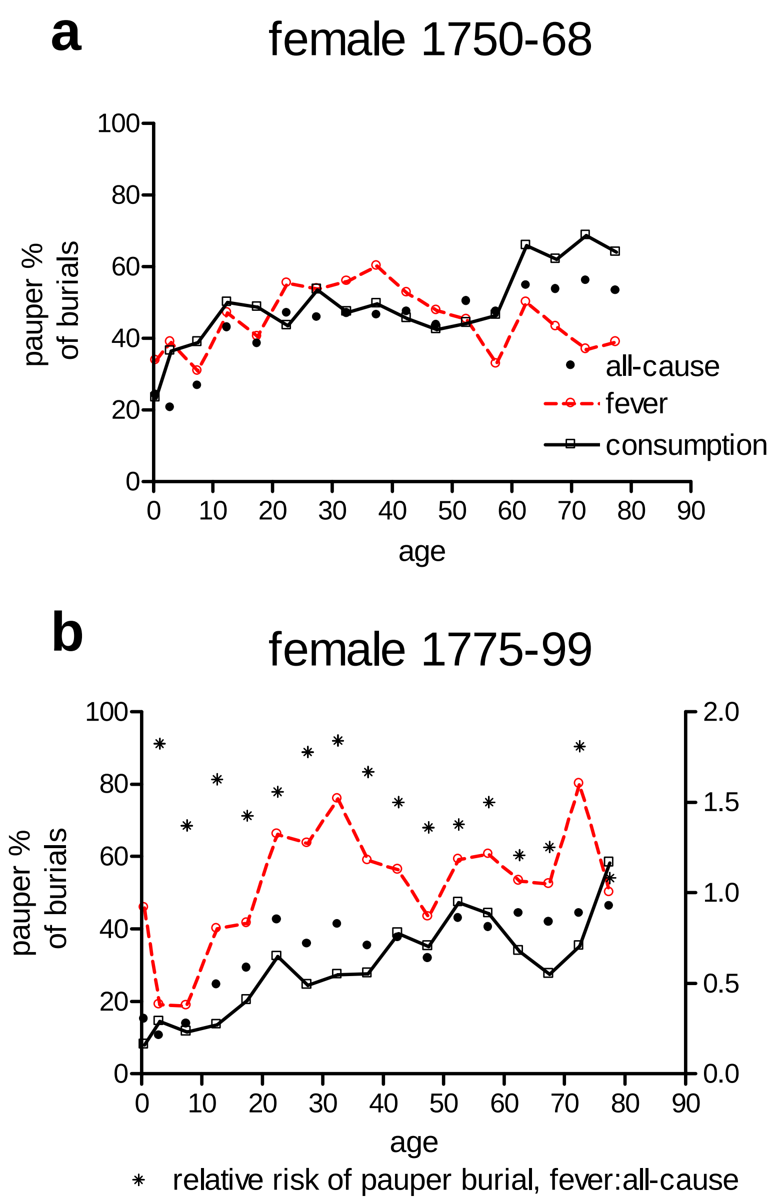

Figure 15. Proportions of consumption, fever and all-cause female burials that were pauper, by age and period.

Taken together, the evidence from the main causes of death in young adulthood did not support McNeill's model, that predicted higher infectious disease mortality amongst young adult migrants compared with other adults. The lack of evidence for specific susceptibility of migrants to smallpox suggests that endemicisation of not only smallpox but many other diseases had already occurred in the areas from which most migrants were drawn in this period (predominantly the south-east, according to Schwarz, 1992). Migrants were drawn to London from smaller urban as well as rural areas (Sharpe, 2000), and those from urban areas were likely to have encountered smallpox as children in this period (Razzell, 2003). Alternatively, would-be migrants, aware of the higher risk of the metropolitan environment, may have chosen to inoculate themselves specifically against smallpox (using variolation) (Razzell, 2003: 82). If however smallpox were fairly endemic in the main migrant hinterlands of London[6], then it is likely that other infectious diseases fitting McNeill's criteria were also. This is because the factors that led to the endemicisation of smallpox (growing population density and increasing frequency of contacts between subpopulations) would have influenced many epidemic diseases similarly[7]. Although new diseases could rise, or old diseases resurge, in an epidemic fashion, they would experience relatively rapid endemicisation under these conditions. From the mid-1770s young adults were relatively free of smallpox in St Martin's, and it is possible that this was the point at which young adults began to display the unusually low mortality, relative to other age groups, that characterised age-specific mortality in St Martin's in the early nineteenth century (such a turning point is suggested in the estimates of ASMRs in Fig 12).

Conclusions

This paper attempted to provide an outline of young adult mortality in the large London parish of St Martin in the Fields in the eighteenth and early nineteenth centuries, and to test whether there was evidence for either an epidemiological disadvantage or a selective mortality advantage of young adult migrants to London. The nineteenth century census and burial data provided a sufficient basis to estimate age-specific mortality rates for the parish, and indicated that young adults were at an unusual advantage, relative to other age groups and to their peers nationally. Mortality in young adulthood is usually characterised by a pronounced 'trauma hump', attributable to the peculiar age-specificity of some diseases (such as tuberculosis and more recently HIV), as well as accidents, and for women the risks of pregnancy and childbirth. In the mid-nineteenth century the English population showed a distinct trauma hump, and this was especially pronounced in the case of females, suggesting that tuberculosis was a major cause of both the young adult mortality excess and female disadvantage. However this trauma hump was absent in the St Martin's population in the 19th century, and probably also in the late 18th century at least, in contrast to the national population in this period. Since the young adult ages were those where new immigrants were concentrated in the London population, there was no evidence in this period for any mortality disadvantage to young migrants, Rather it seems likely that the presence of migrants accounted for the lack of the young adult trauma hump, because they more robust on average, and specifically less likely to suffer chronic disease such as tuberculosis.

---

[6] Endemicity is a poorly defined term, and does not preclude regular epidemics. Endemicity implies that the disease is always present in the population, but the disease may still show regular epidemics, if for instance the number of susceptibles is renewed in some periodic manner. Thus smallpox is described as endemic in London throughout the 18th century but the frequency of epidemics appears to have increased from three yearly to two-yearly around 1750 (Duncan et al., 1996).

[7] Indeed, smallpox was less contagious than many other epidemic diseases (Anderson & May, 1991: 70), and infectiousness coincided with symptoms (reducing the mobility of the infected and making them easier to avoid or confine). Therefore smallpox probably took longer to become endemic than many other major infectious diseases, since it would have required a larger population or more frequent contacts to sustain transmission.

There are no data on population size or age structure of St Martin's in the eighteenth century, and estimates of age-specific mortality rates are necessarily tenuous. However it is likely that any trauma hump that may have existed in the 1750s was relatively small, and diminished over the half century to 1800. The absence of population totals made it difficult to estimate changes in levels of mortality over time, so it was not clear whether any improvement occurred in the mortality rates of young adults, as implied by a disappearance of a trauma hump. Maternal mortality was the only rate that could be calculated (from baptism totals) and the rate of decline was slight and consistent with the national level and trend calculated by Wrigley et al. (1997). However there was a large decline in endogenous infant mortality over the period, that substantially exceeded the national rate of decline. While it might be expected that improvements in endogenous infant mortality would depend upon improvements in the health of young adult females, this did not seem to be the case at the national level, and probably was not the case in St Martin's. Interestingly, endogenous mortality in St Martin's converged to the national level, and this convergence seems to have occurred throughout the country, regardless of earlier levels, suggesting some very widespread factor that emerged in the eighteenth century. Overall infant mortality in St Martin's also approached the national average by the 1820s, from much higher levels in the late 18^{th} century, and this coincided with the virtual disappearance of smallpox, which mainly affected children by this period. Thus by the 1820s endogenous and overall infant mortality were no longer seriously in excess of the national average, while young adult mortality may have been lower than the national average. By contrast, older children and older adults appear to have remained at higher than average risk, presumably reflecting the continuing consequences of high population density and other urban disamenities.

While the low risk of young adults in St Martin in the Fields could be fairly well established, at least for the nineteenth century, the paper also attempted to analyse the contribution of migrants to this pattern, via the more speculative argument that migrant burials were mainly pauper (and the less controversial one that they were also mainly female). This argument relied on the very low sex ratios amongst young adult pauper burials, compared to more equal sex ratios at higher burial costs, that suggested that the surplus of young adult females created by female immigration for service was accorded mainly pauper burials. In the case of smallpox, which Landers and Galloway considered to be confined to children and new migrants, the high sex ratio and relatively high burial costs of the adult burials made it unlikely that typical migrants, who were assumed to be mainly poor and female, were the principle victims. The evidence rather suggests that smallpox was already endemic in the areas from which most adult migrants were drawn. If this pattern of endemicisation also applied to other epidemic diseases then any period of high migrant risk, if it ever occurred, must have been before 1750. The evidence with respect to the burial category 'fever', which probably contained other infectious diseases fitting McNeill's model, was more difficult to interpret, but did not indicate that young adult paupers (and therefore migrants) specifically were more susceptible to infectious diseases described as fevers. Similarly the evidence regarding burials attributed to consumption did not provide clear-cut evidence that migrants were less likely to suffer tuberculosis, although the lower proportion of young adult paupers amongst consumption burials in the last quarter of the 18th century was suggestive of some advantage compared to non-paupers.

On balance the evidence from St Martin in the Fields supported the migrant selection hypothesis, rather than McNeill's endemicisation model, for the period 1750-1850. If tuberculosis were the main cause of the young adult trauma hump and female disadvantage in the national population in the later 18th and early 19th century, as it was after 1850, then young adult migrants to London were probably less likely be actively debilitated by the disease. Tuberculosis sufferers may have been less willing to migrate, and migrants who were debilitated by tuberculosis more likely to leave the capital. Such a migration pattern has been proposed to account for the moderate levels of tuberculosis mortality in some cities (including London) and the surprisingly high rates in some rural areas, despite the traditional association of tuberculosis with crowding and urban environments (Woods & Shelton, 1997).

While the St Martin's population, and London's population more generally, may have become self-sustaining, in the sense of achieving natural increase, by 1800, London still constituted a drain of young adult labour from other areas. The high proportion of young adults created a favourable dependency ratio in the capital, but would have raised dependency ratios in areas of emigration. If additionally the most robust were more likely to emigrate, then this would have exacerbated the dependency burden in rural areas. If this pattern of migrant selectivity extended into earlier periods, when migrants may have been more likely to lack immunity to many endemic urban diseases, then it may well have increased mortality rates nationally, by diverting the more robust young adults to the most dangerous disease environment. By the early nineteenth century, and probably before, young adult mortality rates in St Martin's were no longer excessive. However, if as argued this were a consequence of the robustness of migrants, rather than the salubriousness of the urban environment, then this pattern of migration would have continued to inflate young adult mortality at the national level, by removing the healthiest young adults to less healthy environments.

References

Duncan CJ, Duncan SR & Scott S (1996) Oscillatory dynamics of smallpox and the impact of vaccination. *Journal of Theoretical Biology 183*: 447-54

Floud R, Wachter K & Gregory A (1990) *Height, Health and History*. Cambridge University Press, Cambridge.

Galloway PR (1985) Annual variations in deaths by age, deaths by cause, prices, and weather in London 1670-1830. *Population Studies 93(3)*: 487-505

Landers J (1986) Mortality, weather and prices in London 1675-1825: a study of short-term fluctuations. *Journal of Historical Geography 12(4)*: 347-64

Landers J (1987) Mortality and metropolis: the case of London 1675-1825. *Population Studies 41(1)*: 59-76

Landers J & Mouzas A (1988) Burial seasonality and causes of death in London 1670-1819. *Population Studies 42(1)*: 59-83

Landers J (1993) *Death and the Metropolis*. Cambridge University Press, Cambridge.

Lee R & Lam D (1987) Age distribution adjustments for English census, 1821 to 1931. *Population Studies 37(3)*: 445-64

McNeill WH (1980) Migration patterns and infection in traditional societies. In Stanley NF & Joske RA (eds) *Changing Disease Patterns and Human Behaviour*. Academic Press, London: 28-36

Razzell P (2003) *The Conquest of Smallpox*. 2nd edn, Caliban Books

Sharpe P (2000) Population and society 1700-1840. In Clark P (ed) *The Cambridge History of Urban Britain vol. II 1540-1840*. Cambridge University Press, Cambridge: 491-528.

Schwarz LD (1992) *London in the Age of Industrialisation*. Cambridge University Press, Cambridge.

Schwarz L (1999) English servants and their employers during the eighteenth and nineteenth centuries. *Economic History Review 52(2)*: 236-56.

Woods RI & Shelton N (1997) An Atlas of Victorian Mortality. University of Liverpool Press, Liverpool.

Wrigley EA & Schofield RS (1989) *The Population History of England 1541-1871*. Cambridge University Press, Cambridge.

Wrigley EA, Davies RS, Oeppen JE & Schofield RS (1997) *English Population History from Family Reconstitution 1580-1837*. Cambridge University Press, Cambridge.