Chapter 9

Looking forward to look back: How investigations of historical burial populations can inform our interpretations of prehistoric burial practice

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Introduction

The study of ancient child mortality is essential to the comprehension of demographic processes in the past, as well as the understanding of prehistoric cultures. The fitness of a society's offspring is one of the best indicators of its overall health and well-being (Meckel 1990). From a bio-anthropological perspective, the age at which children die can yield important information about hygiene and medical practices during infancy; nutrition; parental investment; environmental hazards; and the seasonality and age distribution of certain epidemics (*ibid.*). On a more theoretical level, the number, sex, and status of children reared can be indicative of reproductive attitudes, economic niche, social stratification, the commoditisation of children, and social behaviours such as gender preference in hereditary succession (Scott 1999). In the study of funerary behaviour the inclusion of children, or of specific children, can inform archaeologists about concepts of social maturity, religious beliefs and ritual processes (Waterman and Thomas, 2011) among other things.

Despite an increased interest in juveniles in archaeology in recent decades, the dearth of reliable demographic data gathered during previous research continues to inhibit the study of children in past cultures (Chamberlain 1997). One persistent impediment is the reliance on the untested assumption that infant and child mortality in past populations must have been 'high' (Caldwell and Caldwell 2003; Lewis and Gowland 2007), even though excavations of burial sites often yield 'low' quantities of juvenile skeletal remains (Baker *et al.* 2005; Buckberry 2000). It is generally believed that life in prehistoric times was 'nasty, brutish, and short', characterised by high rates of infant mortality and an acceptance of juvenile death as a harsh inevitability (Waterman and Thomas 2011, 178). The dissonance between the expectation of large numbers of infant deaths and the low frequency of discovery of infants in the burial record might be explicable through the effects of taphonomic disruption (Surovell *et al*. 2009) or could be the result of particular funerary practices (Brothwell 1972, 75). Despite wide recognition of the apparent under-representation of infants and young children in the burial record, the relationship between infant mortality, differential burial, and taphonomic factors has not yet been well-established even in more modern historically-documented populations, such as those of the Post-Medieval period.

Infant mortality is defined as the proportion of live-born infants who die in the first year of life. Currently it ranges from as little as 0.2% in industrialised countries like Sweden, to values of over 20% in some developing countries (Barbieri 2001; Department of the Interior 2012; Kuehn 2008; Monnier 2001; Matthews and MacDorman 2007). Model life tables (which are based on mathematical mortality functions fitted to empirical data from stable populations with varying age-specific mortality rates) imply that populations with the lowest average life expectancy can experience infant mortality as high as 40% (Caldwell 1996; Coale and Demeny 1983). Other estimates of infant mortality for pre-transitional populations range from 15% to 30% and above (Buckberry 2000; Hollingsworth 1968). Since the industrial revolution, infant mortality has declined markedly, both in western European and in many developing countries (Caldwell 1996; Monnier 2001). However the perception that infant mortality transitions smoothly from 'high' to 'low' levels may be overly simplistic (Caldwell 1976). In actuality, increases in infant mortality were sometimes observed during the industrial revolution, for example in England and the United States (Meckel 1990; Newman 1906).

Researchers such as Djuric *et al*. (2011), Guy *et al*. (1997), Buckberry (2000) and Manifold (2013) have published preliminary studies into skeletal preservation as one factor that may affect estimates of a population's infant mortality based on excavated skeletal samples. Without a better understanding of what the actual mortality was, however, such inquiries encounter a paradox, wherein a low number of infants preserved is perceived to be *demographically* abnormal, and a high level of infants recovered is perceived to be *taphonomically* abnormal. Rather than being seen as an accurate reflection of mortality, the apparently common under-representation of infants in mortuary assemblages has typically been attributed to differential burial practices, taphonomic factors, incomplete sampling or a combination of these factors (Baker *et al*. 2005; Brothwell 1972; Buckberry 2000; Fazekas and Kosa 1978; Scheuer and Black 2000). In studies of prehistoric populations these problems are multiplied. Not only is initial infant mortality unknown, but the sample sizes of excavated burial sites are typically small (Smith and Brickley 2009), burial traditions are diverse and in some instances hypothesised, and a longer period of time has elapsed since burial allowing the effects of taphonomic processes to accumulate further (Kinnes 1975).

Another line of research into ancient infant mortality has sought to compare the results of cemetery excavations with associated mortality estimates derived from burial records, in order to determine the reliability of mortality data in particular skeletal samples (Grauer and McNamara 1995; Lanphear 1989; Murphy 2016; Saunders *et al*. 1995). The preliminary results from these studies have indicated that a substantial and representative portion of the buried population may be present when excavation is thorough. By studying historic burial records it is feasible to estimate the true mortality of the population which contributes the burials to a cemetery. Furthermore, it is possible to create a baseline approximating how many infants may be lost from a historic cemetery, predicated on use-history and taphonomic processes. This may be accomplished by comparing the divergence between recorded mortality figures and estimates calculated from the age distribution of excavated skeletons, in conjunction with spatial analysis of burial densities. Once such a baseline is established, it may be used for comparison with societies which presumably had even higher mortality, and were subject to the cumulative effects of taphonomic forces acting over hundreds or thousands of years.

Explanations for 'missing' infants and children

Three distinct arguments continue to be invoked for discrepancies between expected levels of mortality and observed numbers of infants and children recovered in cemetery excavations:

1. Children were given different mortuary treatment, either being buried elsewhere or being disposed of in ways that do not favour archaeological preservation (Brothwell 1972; Buckberry 2000).
2. The remains of children and infants were buried at the same locations as those of adults, but their skeletons do not survive as well as adult remains for intrinsic (*i.e.* physico-chemical) reasons (Baker *et al*. 2005; Fazekas and Kosa 1978; Scheuer and Black 2000).
3. Juvenile skeletal remains survive but are more likely to be overlooked by excavators because of disturbance, incomplete sampling, or inability to recognise them (Buckberry 2000; Lewis and Gowland 2007).

The argument that children were buried elsewhere is often inadequate as an explanation for a deficit of children in the mortality profile. If spatially separate child cemeteries or portions of cemeteries allocated exclusively for infants and children were typical, and the population under study had high levels of child mortality, one would expect to encounter child cemeteries with comparable frequency to adult cemeteries. In the historic period, the unceremonious disposal of children is simply not consistent with Christian attitudes about the resurrection of the body, nor the Beautification of Death movement, which emphasised the social pride taken in providing a decent burial for one's family members (Heilen and Gray 2010). There are some regions and time periods when the segregation of child burials was practiced (*e.g.* the *cillini* cemeteries reserved for the burial of children in early historic Ireland: Finlay 2000) but inclusion of children within cemeteries of all ages and both sexes was the norm in European countries in the historic period.

In European Neolithic populations, the issue of burials in separate locations is a more difficult question to resolve. It is possible that child burials were placed away from tombs and settlements and were highly dispersed, therefore tending to evade archaeological detection because of their small size and isolation compared to more conspicuous monumental burial places (Brothwell 1972; Kinnes 1975). However, one of the principal features of the Neolithic transition in western Europe is considered to be the collectivisation of burial (Waterman and Thomas 2011). In most excavated Neolithic burial places, at least some pre-adult remains are included. Of the 16 samples utilised in this study, only three lacked infants entirely, while all included some children under the age of ten years. Clearly mixed-age burial was by no means proscribed. On the other hand, some chambered tombs, such as Notgrove, Point of Cott, and Thickthorn Down included an unusually high proportion of infants compared to a small absolute number of adults (Barber 1997; Drew and Piggott 1936; Smith and Brickley 2009).

This may indicate that certain places were more favourable for infant burials.

The second argument, namely that juvenile bone does not preserve as well as adult bone, is also losing credence. In taphonomic studies, immature bone tends to be similarly preserved to adult bone, and the elements present do not differ substantially between adult and child remains (Djuric *et al*. 2011; Lewis and Gowland 2007). This would imply that if infant bone typically disintegrates faster than adult bone, it does so suddenly, and completely, upon reaching some unknown threshold (Guy *et al.* 1997). If this were the case, the discovery of numerous empty, infant-sized grave cuts would be anticipated during the excavation of inhumations. So far, this has not been attested by archaeological evidence. Similarly, if infant bones are intrinsically weaker than those of adults, their survival relative to adult bones should become rarer the farther into the past one looks (due to the cumulative effects of taphonomic attrition). In addition, the preservation of infant bone ought to be comparatively poor. The presence and occasional prevalence of infant bone in Neolithic contexts clearly contradicts this argument. In Neolithic populations, especially in single interments, the skeletons of children may even be found to be in very good condition (Harris 2010; Mercer and Healy 2008).

The third argument, the failure to identify infant burials, is gaining credibility. Although the retrieval of child and infant remains has increased in recent decades in tandem with improved osteological techniques (Buckberry 2000) there is evidence that infant remains in particular are still routinely under-enumerated. Most osteoarchaeological studies of inhumation cemeteries do not analyse the disarticulated skeletal remains that were re-deposited following truncation and disturbance of earlier burials. In instances where these disarticulated remains have been studied they typically show considerably higher proportions of infant and child remains than are observed amongst the intact burials (*e.g*. Dawes and Magilton 1980, 26; Sellevold and Hommedal 2008, 82). Thus the standard osteoarchaeological practice of ignoring disarticulated remains from cemetery contexts is a likely source of bias in studies of mortality in past populations.

Neolithic Mortality Patterns

Kinnes (1975) commented on the demographic structure of a sample of skeletal remains of 232 individuals from 53 British Neolithic non-megalithic long barrows. His study showed that the overall sample contained 22% sub-adults, though with much variation amongst sites with many long barrow assemblages including no children at all. Subsequent assessments of data on skeletal remains from early Neolithic long barrows (Thorpe 1984) and of recently excavated or re-analysed Neolithic long barrow and chambered tomb assemblages from southern Britain (Smith and Brickley 2009) have determined the sub-adult proportions in these assemblages to be slightly higher at 31% and 26% respectively. These figures suggest some under-enumeration of sub-adults in the Neolithic long barrow and chambered tomb samples when compared to model life table estimates, which predict that in populations with high mortality rates 50% or more of deaths will occur before the age of 20 years (Coale and Demeny 1983). To their credit, many of the early excavations, such as those included in the present study, took care to identify pre-adult remains (Hedges 1984; Mercer and Healy 2008; Renfrew 1979) and ongoing re-analysis of the remains from Neolithic tombs is providing more reliable estimates of individual age at death for some assemblages (Smith and Brickley 2006; Whittle *et al*. 1999; Whittle and Wysocki 2007; see also Silva 2003 for similar research on Portuguese Neolithic tombs).

During the Neolithic the added dimension of secondary burial practices, such as disarticulation and defleshing, might have resulted in the loss of small infant bones, as they were manipulated and moved about in the tombs (Thomas 2000). Another explanation for the apparent deficit of sub-adults in the barrows is that burials of adults took precedence at these collective burial sites whereas sub-adults were more likely to receive alternative funerary rites at other locations. Interestingly the proportion of sub-adult remains in burials in the ditches of causewayed enclosures has been estimated to be 59% (Thorpe 1984), and articulated child burials at these enclosure sites have also been observed to exhibit good preservation (Harris 2010). Sub-adult remains are also more common at Neolithic cave burial sites in Britain, with 38% of individuals belonging to that age category (Chamberlain 2012).

In light of the availability of improved aging data for British Neolithic skeletal assemblages, and recent progress in studies of archaeological mortality estimates, it is timely to revisit the issue of childhood – particularly infant – mortality in past populations. This study aims to establish baseline osteoarchaeological estimates of infant mortality in excavated assemblages of human remains from historical cemeteries that can be validated by comparing those estimates with corresponding documentary data from burial registers This will enable us to gain an understanding of the reliability of mortality estimates based on analyses of skeletal remains, and will allow inferences to be made from infant mortality data collected from a range of British Neolithic mortuary contexts.

Methods

Two excavated post-medieval cemeteries were studied along with their corresponding parish burial records, as part of a wider study of infant representation in historical period cemeteries (Murphy 2016). These sites were St.

Benet Sherehog (SBS), London, England, in use from 1670–1850 (Miles and White 2008) and Alameda Stone (AS), Tucson, Arizona, USA, in use from 1851–1875 (Heilen and Gray 2010). Over 1,860 burial records between the years 1716–1849 from the combined London parishes of St. Benet Sherehog and St. Stephen Walbrook (Bannerman and Bannerman 1920) were compared with the age-at-death structure of 230 skeletons excavated from the churchyard of SBS (Miles and White 2008), while 5,099 burial records (*c.* 1875–1909) from the Tucson parish of San Agustin (Thiel 2012) were compared with the age structure of 1,166 burials excavated from the associated AS cemetery (Heilen and Gray 2010). The ages at death were aggregated into six age categories to facilitate comparison between historical and anthropological data: 0–1.9 years (infants and young children), 2–11.9 years (older children), 12–17.9 years (adolescents), 18–34.9 years, 35–49.9 years and 50–99.9 years (young, middle and old adults respectively). These categories were selected because they corresponded with the most discernible age groups utilised in published reports on the osteological samples. The percentage of deaths in each age category from the burial records was compared to the percentage of deaths in each age category in the excavated osteological assemblage. The resulting deficit between the osteological sample and the records was then examined for patterns within and between the two populations. Possible trends were noted for comparison with Neolithic populations.

The British Neolithic samples consisted of 11 chambered tombs and long barrows, two regional groups of caves with Neolithic burials, and three causewayed enclosure sites. These sites were chosen because the reports used sufficiently precise age categories (including subdivisions of the pre-adult category) which allowed us to compare our estimates of infant mortality amongst the populations. The sites included are presented in Table 9.1.

The chambered tombs and long barrows/cairns include stalled/chambered cairns from the Orkney Isles in Scotland, and long barrows and cairns, the majority of which are from the Cotswold–Severn group in southern Britain. The Orkney stalled/chambered cairns comprised a large enough sample to allow separate examination of this category of tomb. While it was initially hoped that more causewayed enclosures could be included, the lack of precise age estimates for skeletal remains limited the sample to three sites (Curwen 1934; Whittle *et al*. 1999; Mercer and Healy 2008). The White Peak cave system group was aggregated from a recent osteological re-analysis of human remains from 15 caves with Neolithic direct dates (Papakonstantinou 2009). The North Yorkshire cave group included four caves in the North Yorkshire Moors, and 14 caves in the Yorkshire Dales (Leach 2015). Most of the tombs and causewayed enclosure sites were excavated at early dates, ranging from the mid-1800s to the late 1900s, although several skeletal assemblages have been re-analysed using more modern osteological methods (Smith and Brickley 2006;

Table 9.1. British Neolithic sites utilised

Sites	*Excavation date*	*MNI*	*Source*
Chambered tombs and long barrows/cairns			
Thickthorn Down long barrow	1936	5	Drew and Piggott 1936
Notgrove long barrow	1881	10	Smith and Brickley 2006
Sale's Lot long barrow	1936	21	O'Neil 1966
West Kennet long barrow	1855–6	39	Piggott 1962; Whittle and Wysocki 2007
Ascott-under-Wychwood long barrow	1965–73	49	Chesterman 1977
Hazleton North long cairn	1979–82	41	Saville 1990
Whitwell long cairn	1988	16	Vyner 2011
Parc Le Breos Cwm long cairn	1870	35	Whittle *et al*. 1998
Isbister stalled cairn	1958–75	85	Hedges 1983; Lawrence 2006
Quanterness chambered cairn	1972–4	157	Renfrew 1979
Point of Cott stalled cairn	1984	13	Barber 1997
Chambered tombs total MNI		*728*	
Causewayed enclosures			
Whitehawk Camp	1929, 1932–3, 1935	8	Curwen 1934
Windmill Hill	1922–3, 1925–9, 1957–8, 1990	6	Whittle *et al.* 1999
Hambledon Hill	1974–86	77	Mercer and Healy 2008
Causeway enclosures total MNI		*91*	
Cave groups			
White Peak (Derbs/Staffs)	1870–2009	110	Papakonstantinou 2009
North Yorkshire	1860–1985	76	Leach 2015
Cave groups total MNI		*186*	

Whittle *et al*. 1999; Whittle and Wysocki 2007). All of the osteological assemblages from the cave sites were analysed recently, though some of the remains were recovered from early excavations.

Results

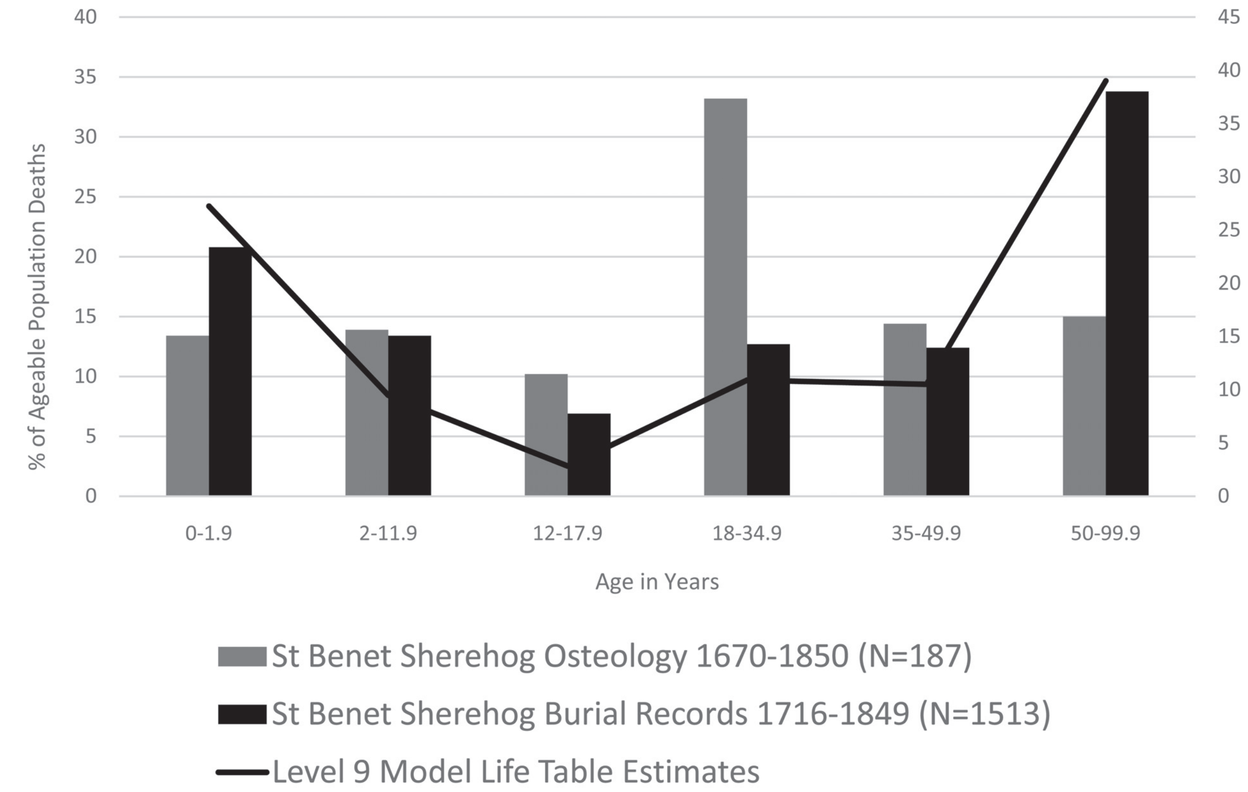
The first stage of the analysis involved the study of two historic cemeteries. Mortality for the osteological samples and burial records for SBS and AS, compared to plausible model life table mortality estimates, are presented in Figures 9.1–2. These profiles tell the stories of two different populations. From the burial records, infant/young child mortality is much lower in SBS (21%) than in AS (37%). Though the value for SBS is relatively low, both infant/young child mortality figures are plausible as realistic infant mortality estimates for the historical era, and demonstrate how urban populations may vary during one time period. The mortality pattern at SBS can be approximated by mortality in a West model Level 9 stable female population with average life expectancy at birth (e_0) of 40 years and annual growth rate (r) of 0.5%, whereas AS resembles a Level 5 stable female population with e_0 = 30 years and r = 0.5%. (Coale and Demeny 1983).

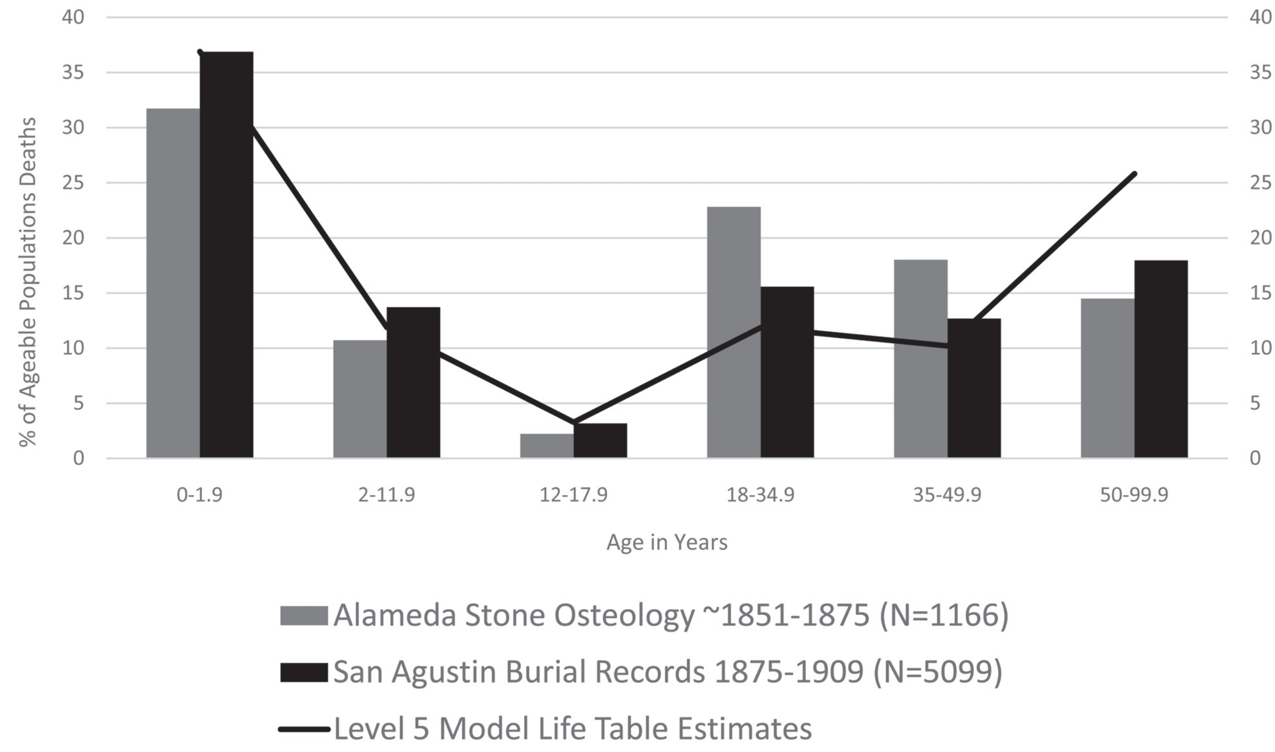
Comparing the estimates of mortality from the burial records and the osteological samples, a deficit of 5–8% in the osteological mortality (as a proportion of total mortality) was observed in the youngest (infant/young child) age category for both populations. There was no apparent deficit in the osteological data for older children in the SBS population, but a small deficit in the osteological representation of older children was observed in the AS population. While these results should be interpreted with caution until they can be tested against more populations, this would imply that the loss of skeletal evidence for infants and young children due to intrinsic factors may not be as severe as has previously been implied. The osteological mortality profiles for the adult portion of both populations exhibit an excess of young adults (18 to 35 years) and deficit of old adults (50+ years), a pattern that is particularly marked in the SBS dataset. A similar pattern of distortion of the adult osteological mortality profile has been observed in several palaeodemographic datasets from different time periods and has been explained as being due to systematic methodological biases in the estimation of adult age at death (Buckberry 2015; Chamberlain 2006). Traditional anthropological methods of assigning adult age at death allocate mean ages to individuals on the basis of morphological changes in the skeleton (so-called skeletal age indicators). These mean ages are typically calculated using regression equations that are influenced by the age structure of the reference collections from which they are derived, and the estimated mean ages do not reflect the full range of variation in age that is present at each observed stage of the skeletal age indicator.

The second stage of analysis involved the examination of the Neolithic burial datasets. Although many Neolithic tombs and burials have been excavated, few reports have employed sufficiently precise aging data to allow modelling of age-specific mortality (Mercer and Healy 2008). A preliminary comparison was made between pre-adults (usually defined as <17 years of age at death) and adults utilising data from previous reviews of the osteological evidence (Barnatt and Collis 1996; Barnatt and Edmonds 2002; Kinnes 1975; Marsden 1977; Smith and Brickely 2009; Thorpe 1984). These sources, collected by various authors, use slightly varying section points to separate the pre-adult and adult categories. However, as the adolescent age category normally has the lowest age-specific mortality, the effects of these differences in methods are minimal. The results are presented in Figure 9.3.

Overall, pre-adults are moderately well-represented (22–45% across all samples). The proportions of pre-adults in the barrow and burial mound assemblages, however, appear to be lower than the proportions of pre-adults in the caves and causewayed enclosures. Previous authors have noted these discrepancies, with Thorpe (1984, 49) suggesting that adult burials were more preferentially associated with prestigious burial places such as long barrows, and Chamberlain (2012, 84) explaining that the frequency of pre-adults in cave burials was closer to the proportion expected for prehistoric populations with moderate to high rates of mortality.

In order to study infant mortality in greater detail, two regional cave groups, 11 long barrows and cairns, and three causewayed enclosures with more precise aging data were analysed separately and then as aggregates. Figure 9.4 shows the mortality profile within the North Yorkshire and White Peak (Derbyshire and Staffordshire) regional cave groups (data taken from Leach 2015 and Papakonstantinou 2009 respectively), as well as the aggregated data from the causewayed enclosure sites of Hambledon Hill (Mercer and Healy 2008), Whitehawk Camp (Curwen 1934) and Windmill Hill (Whittle *et al*. 1999). The White Peak cave sample showed an infant/young child mortality of 23%, followed by a slight rise in later childhood and an expected drop in adolescence. The mortality profile in this cave group resembles a high mortality model life table with some under-representation of individuals in the infant age category. The mortality profile for the North Yorkshire cave sample exhibits much lower infant and child mortality with correspondingly higher proportions of individuals in the adolescent and adult categories. Although taphonomic factors might account for the differences between the cave burial groups the geological and climatic conditions are similar in the two cave regions and direct radiocarbon dating has shown that cave burial was contemporaneous across the regions. Instead the variation in mortality patterns might be attributable to differences in age and/or status-based burial practices between the regions during the Neolithic. Like





Figures 9.1 and 9.2. Mortality from the St. Benet Sherehog and St. Stephens Walbrook burial records and St. Benet Sherehog osteological sample compared to Level 9 model life table data (top); mortality from the St. Agustin burial records and Alameda Stone osteological sample compared to Level 5 model life table data (bottom).

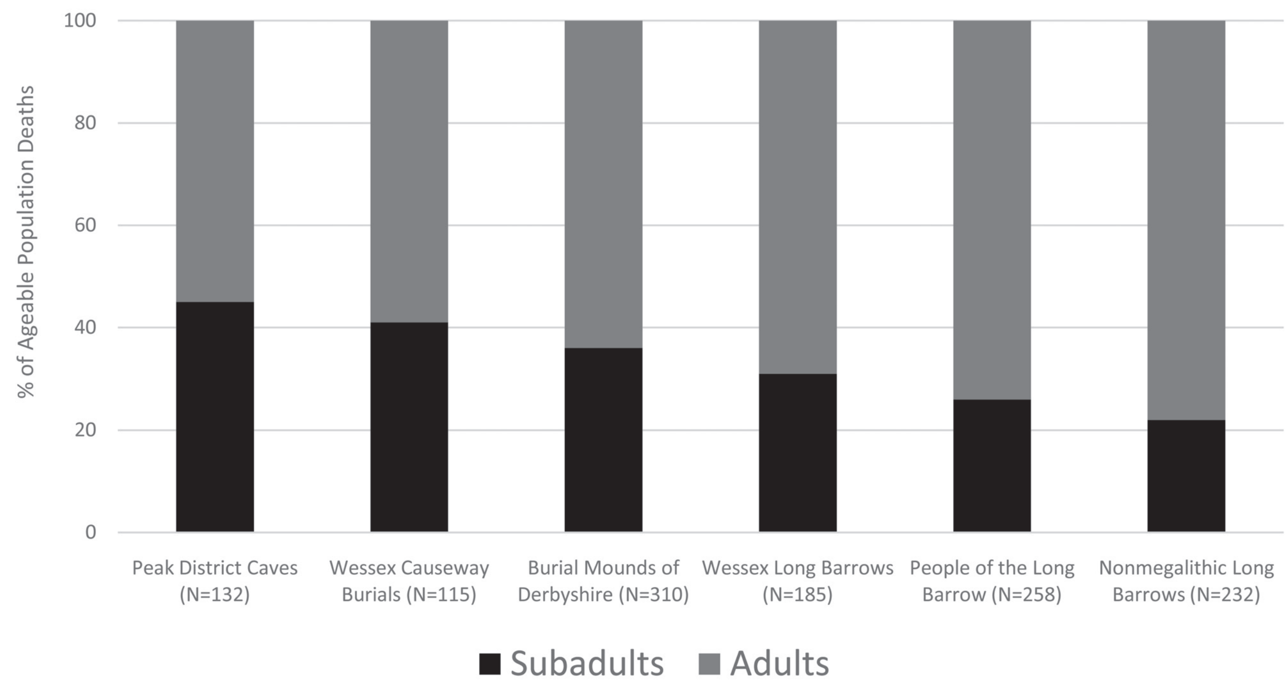


Figure 9.3. Aggregated comparison of sub-adult (<17 years) to adult (>17 years) mortality from various Neolithic sites. Sources: Neolithic/Early Bronze Age burials in Peak District caves (Barnatt and Edmonds 2002), Wessex causewayed enclosure burials (Thorpe 1984), burial mounds of Derbyshire (Marsden 1977), Wessex long barrows (Thorpe 1984), Neolithic long barrows (Smith and Brickley 2009) and non-megalithic long barrows (Kinnes 1975).

the Yorkshire Caves, infant/young child remains were also under-represented at Hambledon Hill (8%). However, the remainder of its mortality profile more closely resembled the White Peaks Caves. Overall, the data presented in Figure 9.4 confirms the presence of high proportions of pre-adults in cave and causewayed enclosure assemblages that had been identified in previous reports (see Fig. 9.3) though with some indication of infant and child under-representation compared to the samples from the historic period cemeteries discussed previously.

The barrow burials were sufficiently numerous to be subdivided into a stalled/chambered cairn group and a long barrow group. The percentage of deaths by age category in the stalled/chambered cairns is presented in Figure 9.5. The stalled/chambered cairns included the largest single samples of Neolithic human remains in the entire study, with the Isbister population including an MNI of 85 individuals and Quanterness including 157 (Hedges 1984, revised by Lawrence 2006; Renfrew 1979). The sample from the Point of Cott cairn was unfortunately much smaller, with only 13 individuals represented (Barber 1997). The varying numbers of individuals buried in the Orkney tombs may reflect complex secondary burial rites (Reilly 2003) and both Isbister and Quanterness had larger interior spaces with multiple side chambers compared to Point of Cott's single burial chamber. Although a small sample, Point of Cott had an unusually high proportion of infants.

Isbister and Quanterness display relatively normal profiles for all age categories but the first. Together these two samples most clearly illustrate the deficiency of infants and young children, with 6% and 7% respectively. There is also a lesser discrepancy in these groups between the 3–11 and 12–17 year old age categories than in some other groups. This may suggest age-dependent burial practices, with infants intentionally excluded.

Eight long barrows and cairns were available for study, ranging in sample size from five individuals to 49 (Fig. 9.6). Half of these tombs include very few individuals in the 0–2 years age category (Whitwell Cairn and West Kennet have none in this age category while Parc le Breos Cwm and Ascott Under Wychwood have 3% and 2% of their ageable individuals respectively). Despite the near absence of infants and young children in these four long barrows, the proportion of older children (3–11 years age category) ranges from 12–25% in the same samples, implying that taphonomic factors do not convincingly explain the missing infants in these samples.

The remaining tombs appear to have had moderately high numbers of infants and young children (14–30%). Notgrove, though only a sample of ten burials, also includes some individuals of all ages, in addition to a high proportion of infants (30%). It displays a similar mortality profile to the Point of Cott stalled cairn. This may suggest that smaller tombs were more likely to include infants. The percentage of 3–11 year olds is 10–27% in all populations. In most

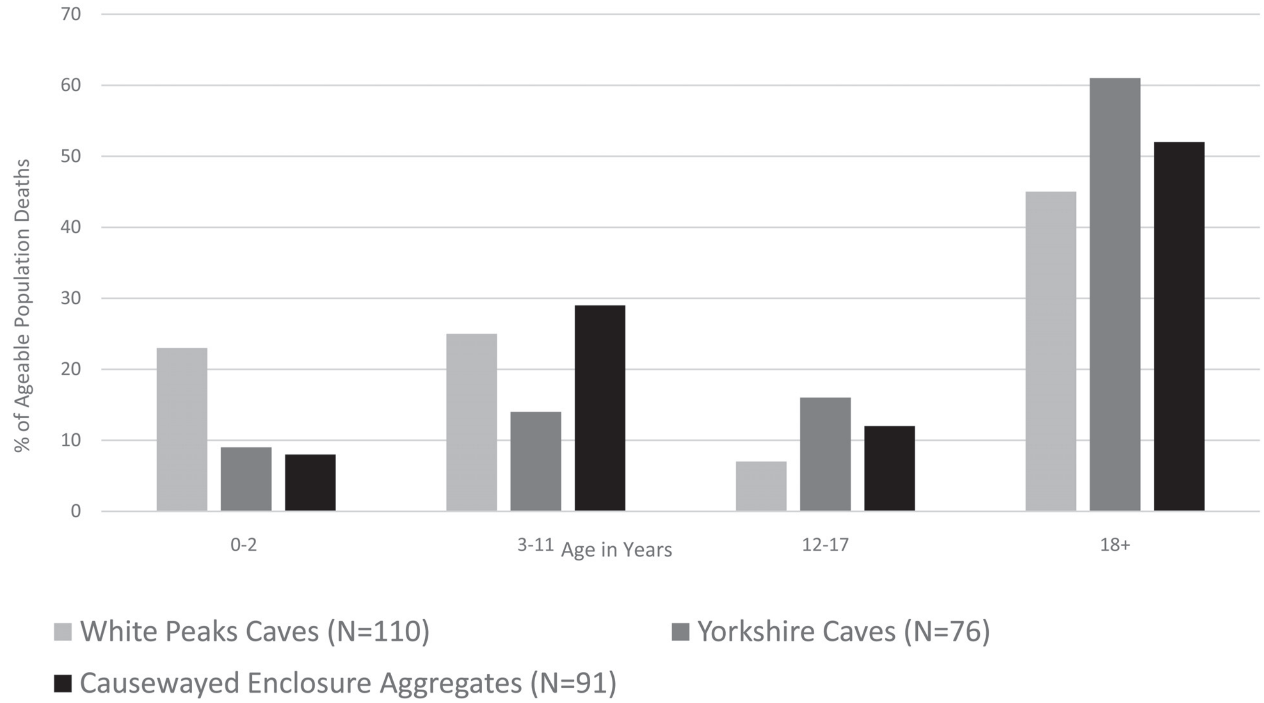


Figure 9.4. Percent deaths by category in the skeletal assemblages from the White Peak and North Yorkshire cave groups, and at causewayed enclosure sites (Leach 2015; Mercer and Healy 2008; Papakonstantinou 2009).

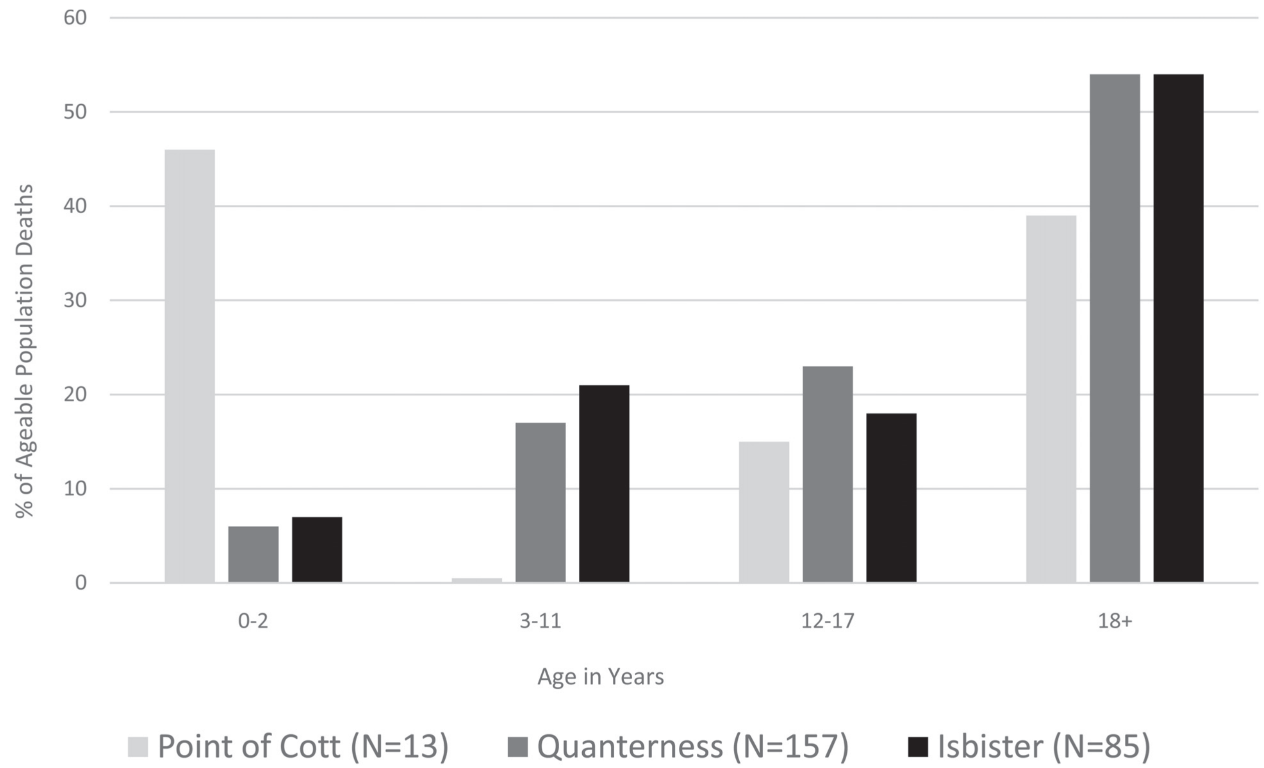


Figure 9.5. Percent deaths by age category from three excavated stalled/chambered cairns (Barber 1997; Hedges 1984; Renfrew 1979).

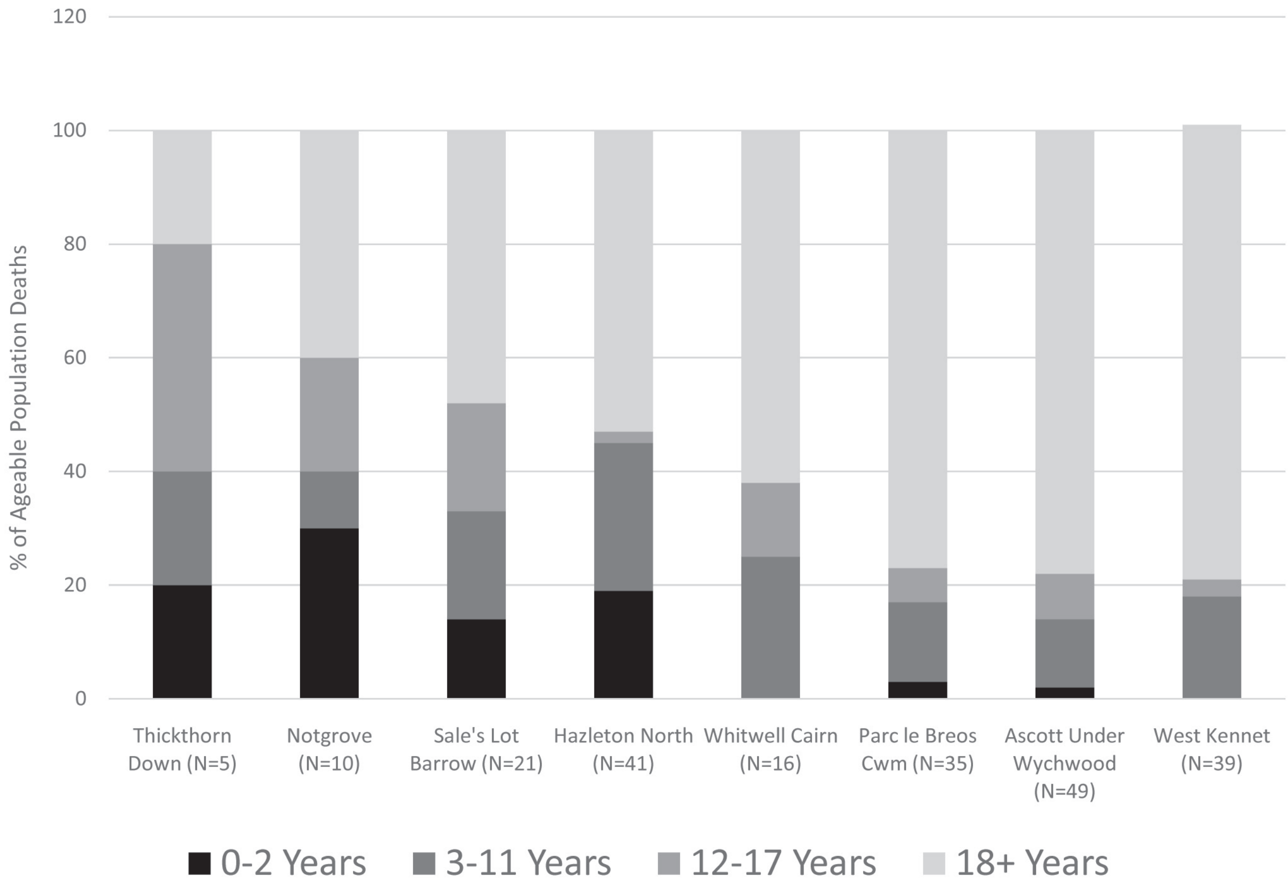


Figure 9.6. Percent deaths by age from eight excavated long barrows.

groups, this is higher than the percentage of 0–2 year olds, and considerably higher than the proportion of individuals in the 12–17 year old age group. In the four largest populations, the 12–17 year old group is negligibly represented at 2% (Hazleton North), 3% (West Kennet), 6% (Parc le Breos Cwm), and 6% (Ascott Under Wychwood). This continuing trend, observed in most Neolithic groups studied, seems to imply that older children were accorded normative burial rites and that their remains were reasonably well preserved.

To attempt to mitigate the effects of small sample size, the sites were aggregated into Causewayed Enclosures, Cave Systems, and Chambered Tombs (Fig. 9.7). When aggregated, both causewayed enclosures and chambered tombs show 8% of their populations in the 0–2 years age group. This figure is considerably lower than would be expected for a historical period population, even accounting for some bone loss. The aggregated cave samples exhibit 17% in the infant/young child category. While this may be affected by minor taphonomic loss, it is a proportion that is only a little lower than expected values for historical period mortality. This may imply that cave burial sites included more infants than chambered tombs and causewayed enclosures initially, or that infant burials were better preserved in caves, or some combination of both. All groups show approximately 20–30% mortality in the 3–11 years group. This is markedly higher proportional mortality than is observed either in the historical-period skeletal samples or in the model life table data. Although a slight excess in the 3–11 years group could be accounted for if infants and young children are under-represented in the Neolithic assemblages, the data imply either that mortality in that category was unusually high in the prehistoric populations, or that children of that age were especially likely to be represented in burial contexts. Elevated mortality in the 3–11 years age category is the more plausible of these explanations.

Discussion

The burial records for the two historic cemeteries in the study exhibited plausible infant/young child mortality figures: 21% and 37% of total mortality occurred in the 0–1.9 year category, respectively. These values agree well with model life table mortality profiles fitted to the respective datasets. Mortality estimates from osteological data were 5–8% lower for the youngest age category for both populations when compared to the documentary records of burials in these populations. If the lower infant/young child proportions in

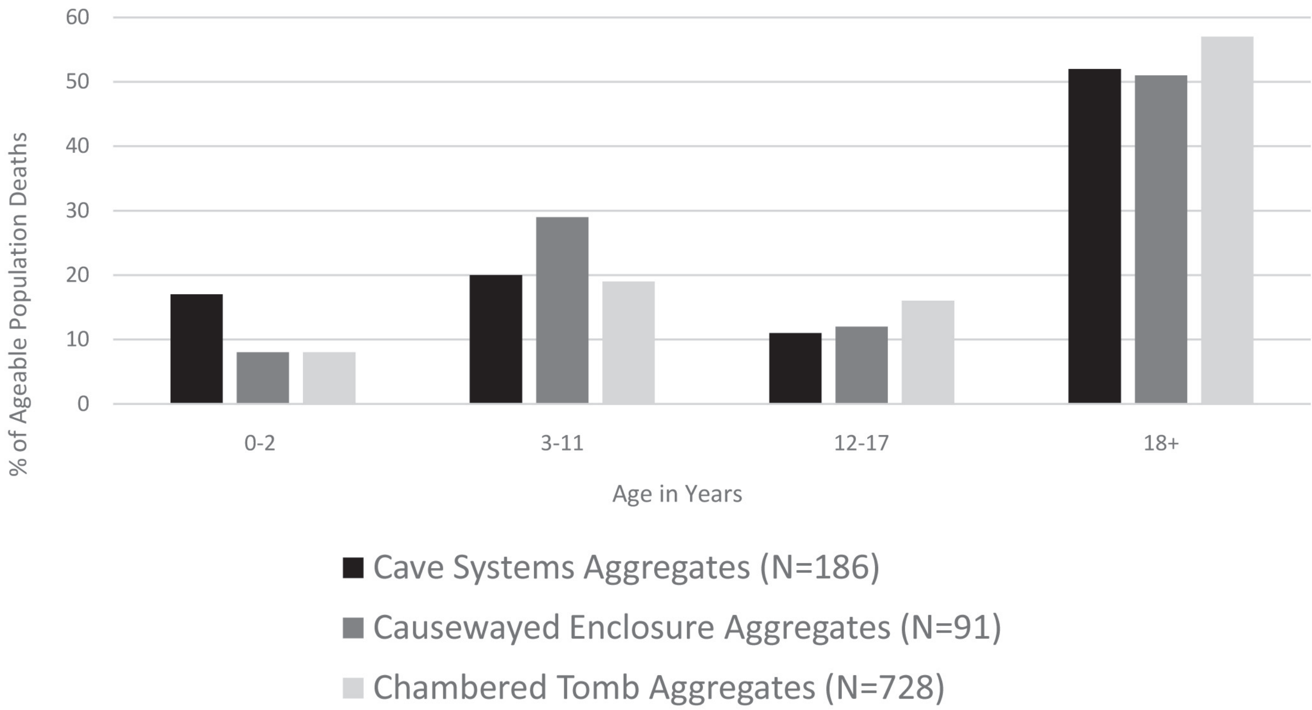


Figure 9.7. Percent death from aggregated excavated causewayed enclosures, cave systems and chambered tombs.

the osteological samples were entirely attributable to post-depositional (*i.e.* taphonomic) loss then these data imply a loss of 20–40% of individuals in the youngest age category (assuming zero taphonomic loss of other age categories). Deficits in the osteological profile for older children were less evident in the historical datasets included in this study, Overall the data from the historical period cemeteries are consistent with hypothesised preservation and/or recovery factors that differentially impact most markedly on the skeletal remains of infants.

Some authors have claimed that variations in skeletal age distributions are determined by variations in fertility rather than in age-specific mortality (McCaa 2002). This assertion can be tested for our historic period cemeteries by calculating the immaturity ratio – the proportion of the population aged between 5 and 19 years (Bocquet-Appel 2002), a demographic parameter that has a high correlation ($r = 0.94$) with population growth rate. For the SBS and AS cemeteries the immaturity ratios gave annual growth rate estimates of 0.9% and 0.5% respectively, values that agree closely with the model life table mortality curves fitted to the data (see Figs. 9.1 and 9.2). Although the AS cemetery served a growing Tucson population this population growth was likely generated as much by in-migration of adults as it was by intrinsic population growth.

These findings have three implications for palaeodemographic studies: (1) Infant/young child mortality may not always be uniformly 'high' in pre-transition populations, but may have varied markedly – in the historical samples in this study infant mortality varied by a factor of two; (2) The differential loss of infant and young children's bones from the initial burial population appears to be moderate in the historical populations sampled, with the losses estimated at less than 10% of the initial burial assemblage; (3) Under-representation of children in most of the excavated Neolithic skeletal samples appears to be more substantial for the youngest age category, although the aggregated cave assemblage more closely resembled the historical cemeteries in this respect.

Though both Alameda Stone and St. Benet Sherehog were situated in urban centres, living conditions, climate and occupation were likely quite different. Alameda Stone was a desert frontier community, which was characterised as unsanitary and rough (Heilen and Gray 2010). During the use-period of the cemetery its population was sizable and expanding. Despite this, it lacked the heavy industrial atmospheric pollution and overcrowding of London. St. Benet Sherehog, although a large parish, had only around 230 parishioners at its height, and was experiencing a gradual population decline during the cemetery's period of use (Miles and White 2008). Alameda Stone exhibits high early life mortality, with the greatest percentage of infant deaths clustered around the ages of 1–2 years. This implies high fatality around weaning-age, probably due to the gastrointestinal diseases that would have flourished in Arizona's hot, dry climate (Heilen and Gray 2010). St. Benet Sherehog had a reduced level of infant mortality, owing to the greater proportion of deaths among its elderly. Its infant attrition was clustered in the neonatal period, suggesting unsanitary birthing practices or congenital enfeeblement, such as might be attributed to maternal alcoholism and stress. The geriatric population of Alameda Stone was younger on average than that of St. Benet Sherehog, whose parishioners frequently survived into their 80s and 90s. This may be due to the frequency of occupational accident and/or increased frailty of the elderly associated with frontier living.

In early adulthood, the age categories tended to exhibit a surplus in the osteological sample compared to the burial records. This is due, in part, to the difficulty in determining precise osteological ages for adults above the age of 40, and the assignment of multiple individuals to the same mean age estimate rather than distributing them across the range of possible ages (Buckberry 2015; Cave and Oxenham 2016; Chamberlain 2006). The result is an over-enumeration of skeletal adults in the 18–49.9 years categories, and a deficit in the 50–99.9 years categories. It is also possible that this is part of the explanation for over-enumeration in the 12–17.9 years category in the osteological profile at SBS. The burial records, by contrast, attest that in both populations many individuals survived well above their fifties with up to one third of mortality occurring in the oldest adult age category. A major deficit of more than 50% of expected values is seen in the osteological estimate for 50+ mortality at St. Benet Sherehog. This is particularly interesting in light of the typical belief that few people lived to advanced age in the European Neolithic (see Fahlander 2013 for detailed discussion of this issue, and Cave and Oxenham 2016 for a methodology that can help to mitigate this problem).

Although issues of incomplete or faulty recording may create inaccuracies, a fairly complete burial record (as would be expected in historical period cemeteries serving a well-defined sedentary living community) can be reasonably assumed to provide an accurate initial mortality estimate. In the case of SBS, the burial records were shared between two parishes, though only one cemetery was examined (Miles and White 2008). At AS, the parish burial records were coming into use around the time the cemetery was falling into disuse. As such, records will not be perfect correlates, but they are both reasonably consistent. For example, when recording of burials became mandatory in London following the imposition of the Stamp Duty Act of 1783, neither the composition of the burial register at SBS nor the rate at which burials were recorded changed substantially from the previous years (Bannerman and Bannerman 1920). The parish of San Agustin was the main parish for the entire population of Tucson, both during the use period of the cemetery and after (Heilen and Gray 2010; Thiel 2012). Furthermore, the use period of the cemetery, and the duration of the records, form a relatively discrete time period (around 60 years). Though mortality may have changed during this time, it is probably reasonable to assume that any changes would not have been substantial.

An initial look at Neolithic populations subdivided into pre-adult (<17 years) and adult (>17 years) age categories yielded markedly varying proportions of sub-adults (19–63%). When broken down into more precise age categories, however, it becomes clear that within individual burial loci, infants and young children are typically under-represented. Regional groups of cave burials, causewayed enclosures, and tombs typically included approximately 5% to no more than 20% in the youngest age group. There were some exceptions to this, including the anomalous White Peak regional cave group. At the same time, some populations had an unexpectedly large proportion of individuals in the 3–11 years age group. This is interesting in light of the prevailing belief that tomb inclusion was ancestor-based (see Thomas 2000 and Whitley 2002 for discussion and critique); if so, those without direct descendants apparently could be integrated into the burial system.

In modern populations, age-specific mortality typically drops markedly after early childhood as individuals become more resistant to infection and build greater nutritional reserves. As Neolithic populations were likely too small and dispersed to sustain major epidemic diseases, it is possible that fatal accident was more important as a cause of death, and this would be a risk that was more evenly distributed across age categories. Another possibility is that the ‘missing’ infants are artificially inflating the appearance of the 3–11 age group. In order to create ‘normal’ mortalities for all populations, in which the number of 0–2 year olds exceeded the number of 3–11 year olds at around 30%, the number of infants within the cave systems would need to double, while the number of infants within the tombs and causeway enclosures would need to quintuple.

Three main types of mortality profiles were observed: (1) Excessive deaths in childhood (2) Small but normative ‘family-like’ samples and (3) Linear, status/age-preferential samples. Most of the larger populations, including the aggregated samples, displayed an anomalously high level of mortality in the 3–11 year old group, even where the proportion of infants/young children is high enough to be reasonable. Notgrove and Point of Cott, two of the smaller samples, demonstrated relatively normative mortality profiles. This could indicate that these were drawn from smaller, more inclusive groups. Finally, the Yorkshire Cave group, Isbister, and Quanterness, in particular, display linearly increasing mortality profiles that may indicate age/status preferential burial. These samples, though large and well-preserved overall, appear to have fewer than expected infants and young children, while favouring adults.

When aggregated, the regional cave groups resulted in the most normative mortality profile, although the number of 3–11 year olds was still high. Chambered tombs were the second most normal, with infants under-represented. Causewayed enclosures were the most irregular, with infants lacking, and the highest spike in the 3–11 years age group. This may be due in part to the small number and sample sizes of causewayed enclosures available for study.

Conclusions

Despite the fact that sub-adults are not severely under-represented in some Neolithic populations, the percentages of mortality in the youngest age category of aggregated populations are too low to be a realistic representation of infant mortality at the time. At the same time, some smaller individual tombs demonstrate more complete mortality profiles, making it evident that not only were infants initially included in some cases, they were preserved enough to be recoverable during archaeological excavation. Larger tombs, while often containing some children, may have experienced their loss through post-mortem manipulation, poor retrieval during excavation, or low initial inclusion.

Aggregated cave systems demonstrate the most plausible mortality profile, with an overall infant/young child mortality of 17%, a rise in early childhood, a drop in late childhood, and a high proportion of deaths in the adult group. However, when separated into regional cave groups marked differences are observed between Derbyshire/Staffordshire and Yorkshire in the proportions of infants and children, even though the two regions do not differ noticeably in environmental conditions or in the dates of the burials. This indicates that cave burial customs may have differed between the regions, as they apparently did between categories of tombs. Both causewayed enclosures and chambered tombs display a deficit of infants which far exceeds the 5–6% disparity between burial records and osteological data observed in excavated historic cemetery populations. Despite this, the fact that infants are present at all in the Neolithic implies that the 5–6% deficit recorded in populations from 300 years in the past cannot be extrapolated as a regular rate of loss: a greater deficit in the Neolithic might be expected if there was a cumulative loss of infant remains through time. The fact that mortality in the 3–11 years group is rather high in the same populations (19–29%) also indicates that their mortality profiles are not solely explicable in terms of taphonomic loss, unless the misplacement of small neonatal bones can be postulated. Even where infants are well-represented, mortality typically rises among older children during the Neolithic; a feature which is uncharacteristic of modern mortality. This may imply high risk of accident, which is a common cause of fatality among young children in hazardous environments. It may also imply that four-fifths of the original infants within the causeway and tomb populations are missing, while one-half of the original number of infants in cave systems are missing.

Our findings provide some signposts for future studies of demographic structure from assemblages of human skeletal remains. Further, more detailed comparison of recently excavated skeletons from historic cemeteries with associated burial records will be needed to corroborate the relatively small (5–8%) estimated deficit in estimates of infant mortality from skeletal remains. This will provide the basis for re-studying prehistoric assemblages of skeletal remains with the prospect of discriminating between biases due to taphonomic effects and incomplete recovery on the one hand and culturally determined selective burial practices on the other.

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