SECTION 3.
Palaeodemographic Analysis

Brothwell (1981) states that ‘there are...three primary areas of human demography that can be considered in relation to earlier peoples: a) population growth and decline; b) the composition of communities; c) the distribution of populations in space and time’. The first and third areas are not within the scope of the present work, but the composition of communities will be considered. For such a study it is necessary to determine age at death and sex for each skeleton within a population. Methods and problems involved in these determinations will be discussed in Sections 3.1 and 3.2. Aspects of fertility will be considered in Section 3.3 on parturition.

Palaeodemographic surveys have been carried out based on various regions (e.g. Brothwell, 1972; Hedges, 1982) and on single cemeteries (Boddington, 1982, 1987c). These studies have involved the construction of life tables and sex ratios based on data from research on the skeletal populations. The imprecision of ageing techniques will undoubtedly render the results of these life tables inaccurate, if not completely useless, although sex ratios should be fairly certain. However, as Acsádi and Nemeskéri (1970: 72) point out, ‘Historical investigations in the field of both the biological and social sciences must often rely on demographic information. The necessity of palaeodemographic research is justified by the lack of any other source supplying such information’. In other words, if we hope to find out anything of value about people in the past, it is useful to know age and sex distributions at the very least.

The use of life tables involves a number of assumptions, not the least being that age estimations for the population are at least reasonably reliable. The problems involved in ageing skeletal remains are such that, in the case of adults, there may be a bias towards younger individuals. Older individuals cannot be excluded from the complete table, but they will probably be underaged. Without some form of correction factor, such biased tables cannot be compared with life tables of modern populations.This fundamental problem, which would appear to invalidate the use of life tables in the study of skeletal populations, may be overcome by the use of some more accurate ageing techniques in the future. At present, however, if any analysis of age at death of skeletal populations is to be carried out, it may be of use to construct life tables and graph expectation of life, survivorship rates and probability of death, at least for those populations with a large number of buried individuals and a large proportion of juvenile remains.

Bocquet-Appel and Masset (1982) found a high correlation between age structure of reference populations for various ageing methods and age structure of populations aged using those particular methods. From their study, they suggest that scarcely anything positive can be deduced about the demography of ancient populations. ‘Early mortality of adults, over-mortality of women, lack of old people in these populations, whether prehistoric or medieval: all these hackneyed notions were born from the misinterpretation of data. As they are in no way vindicated, we must get rid of them.’ (1982: 329). However, Buikstra and Konigsberg (1985), although noting other problems with palaeodemography, showed the suggested correlation of study group ages with reference group ages to be incorrect.

Moore *et al.* (1975) consider some of the assumptions made in the use of life tables in palaeodemographic analysis. They list the main problems as being infant underenumeration, population growth and small sample size, but do not examine inaccuracy of ageing a skeletal population. Acsádi and Nemeskéri (1970) list six requirements pertaining to a population to be analysed palaeodemographically, these being (i) completeness of the series, or lack of it, should be known, (ii) accuracy of estimation of age and sex, (iii) information on the series, such as chronology of burials, (iv) the population should be unchanging, no migration, etc., and representative, (v) suitable demographic methods should be used depending on the aim, and (vi) uniformity of analytical work throughout the procedure. None of the populations studied in the current work, or indeed anywhere in the world, can be thought of as complete, and their migratory patterns and representativeness are unknown. However, Acsádi and Nemeskéri carried out extensive studies on a large number of archaeological and historical populations from Europe, and Hungary in particular, and have concluded that ‘the cemeteries of historical populations, forming part of the same people and having been under identical social, economic and cultural conditions, usually correspond to one another in respect of essential demographic characteristics. There may be certain minor local features which differ and these can be explained by the low number of elements in the sample, and so the computed results can be generalized even if only a few series are taken into account’ (1970: 58).

In the current work, graphs and life tables are presented with weighted adult ages (as well as the original age estimates), on the assumption that 50% of the individuals within each adult age group have been underaged by ten years. It is of course likely that a different proportion of adults in each age group could have been under- or even overaged, but it seems possible that the various inaccuracies may be evened out when age groups of ten years are being utilised. For example, if 60% of the individuals in the age group 35-45 years were underaged and a number corresponding to 10% of this group were overaged in the group 45+, a weighting factor of 50% would produce the same result. Without further evidence from known populations, such as Spitalfields (which is not available at the time of writing) it is impossible to be certain of the proportions of individuals in each age group who are likely to have been assigned wrongly. For this reason, a figure of 50% was chosen in order to show the effect such an error would have on the life table of three populations (HIR, MK and JA). These tables and figures are included and studied in detail in section 3.1 on age.

It may be possible to prove with further work that the inaccuracy of age estimation in adult skeletons does not affect the general picture produced from life table calculations. For this it will be necessary to have some indication of the level of inaccuracy, probably from work such as that done on the Spitalfields population. On the other hand, the number of assumptions involved in using these tools of demography on ancient populations may render the whole process invalid.

3.1. Estimation of Age

3.1.1. Methods and Problems

A number of methods of determining the age of a human skeleton are currently in use, some more accurate than others. Methods range from visual, through metrical, to microscopic. In general, human osteologists tend to concentrate on the first when writing reports, with use of the second where necessary. The reason for this is that the last is extremely time consuming, is not available in most centres, and also involves destruction of part of the bone by slicing it into thin sections.

Examples of ageing techniques which fall into the first group include the general appearance of the bones, for example presence of signs of old age (osteoarthritis, osteophytosis, etc.), the appearance of the pubic symphysis, or the stage of wear of the teeth. In the case of a child, the stage of calcification and eruption of the teeth is more appropriate, as well as the stage of fusion of the epiphyses to the long bones. The second group of methods generally involves measuring the long bones of children in order to determine their approximate age. This method is almost as accurate as the stage of eruption of their teeth, but both methods will only give an estimate of biological developmental age, not chronological age.

Microscopic methods of determining age from adult bone include that pioneered by Kerley (1965), which involves the counting of the number of osteons, fragments of osteons and non-Haversian canals in a given area of the femur or tibia. This method (with recent revisions, Kerley and Ubelaker 1978) is probably a far more accurate way of ageing adults, but unfortunately, as stated above, it would take far too long to do this for every skeleton in a group, which makes it unlikely that it would be used in a normal osteological study. It has also been suggested by Ortner (1975) that dietary and environmental factors could influence the histological appearance of the bone, which may reduce the accuracy of the method.

Another microscopic method has been devised for use on thin sections of teeth, in particular the canine (Gustafson, 1950). This involves the study of six features of the sectioned tooth: attrition, periodontosis, secondary dentine deposition, root resorption and transparency of the root. A standard curve is used to estimate age from points allotted to each feature. This method seem to yield accurate results, but are time-consuming and expensive, and are therefore not practicable for most archaeological bone specialists. The assessment of periodontosis (recession of the gingival margin) is in any case difficult in archaeological populations (Hillson, 1986).

Unless one of the microscopic methods is used, the chances of ageing an individual accurately once he/she has reached the age of 25 are very slim. Most bone specialists, nevertheless, give an approximate age range within which the individual would fall with 80-90% probability, although this estimate of accuracy has had to be revised in the light of the evidence from Spitalfields.

The main techniques in use will now be considered in more detail. Those utilised in the ageing of children are considered first, followed by those applicable to adults.

3.1.1.1. Child Age Evaluation

Probably the most accurate method of ageing a child is to inspect the stage of calcification and eruption of the teeth. This involves deciding which teeth are present in the jaw, which are deciduous and which are permanent, and the relative length of the root of each tooth. A scheme based on large numbers of individuals (Ubelaker, 1978) which can be used to determine the age to within a few months in the case of a very young child, or a couple of years in the case of an older child or adolescent, has been recommended by the Workshop of European Anthropologists (1980). This chart was originally prepared from a study of the teeth of modern American children, and we have no way of knowing if the dentition of ancient populations reached the same stage at a similar age as that of the modern child. Although the state of eruption of the teeth is the easiest method to use, since it does not involve radiographic analysis, most osteologists believe that calcification is a more accurate age determinant (Ubelaker, 1987). This is due to the fact that calcification is a more consistently occurring phenomenon than eruption in most populations, since the latter tends to vary from individual to individual.

If no teeth are present, either because the child is too young or because conditions of burial have been unfavourable, another method of determining the age of a child, from six months to 14 years, is to measure the lengths of the shafts (diaphyses) of the long bones. The lengths are then compared with a standard chart (Workshop Eur. Anth., 1980), based on an old Slavic population with an average stature of 171cm for men and 161cm for women (Stloukal and Hanáková, 1978). The problem with this method is that it is based on a small number of individuals of unknown age, and it is therefore recommended that a broader age estimate is given when this method is used. It also assumes that individuals who died as children were not greatly affected by growth disturbing diseases. Sundick (1978:232) presents evidence to suggest that 'the subadult skeletons which are present in our archaeological collections are not very different from those who survived in terms of their size. They may just have succumbed to a relatively stressful situation that lasted for a short period of time'. Presumably, also, children of populations of similar time periods were in general dying for similar reasons, unless some localized epidemic occurred. However, since the method is widely used, it does at least allow for comparison between sites, and when used in conjunction with other estimates of juvenile age it provides greater confirmation of age determinations. Scheur *et al* (1980) have produced regression equations for ageing foetal and perinatal skeletons based on a modern population.

Both methods can be used up to the age of 14-15 years, after which all the adult teeth have erupted (except the third molar, which may not always erupt, and could then only be used in radiological studies of calcification stage), and the bones become a less accurate guide due to divergence between sexes, and the wider range between children of the same age and sex.

From age 14 to 25 the best method to use is the fusion of the epiphyses of the long bones. These are attached to the diaphysis of the long bone by cartilage, which eventually ossifies, at which point the bone no longer grows in length. Approximate ages of fusion for each bone are known, since this process does not occur in all parts of the skeleton at the same age. The state of ossification, or size of the epiphyses, can give an estimate of age (Brothwell, 1981). It is best to consider more than one bone if possible, since this will narrow the range of ages considerably. This method will usually give an accuracy of 3-5 years, based on a modern population.

There are, however, problems in the ageing of child skeletons. Johnston (1969:336) states that the normal range of variation for age at menarche in girls is 6.5 years, and 'an age difference of four years is not at all uncommon between two like-sexed individuals who display the same degree of skeletal maturity'. This suggests that once a child has reached the age of puberty, an estimation of chronological age will be far less accurate than previously. From the age of ten years onwards any age estimate based on skeletal maturation in juveniles or sub-adults may be out by as much as 5+ years.

3.1.1.2. Adult Age Evaluation

After the age of c.21, all the teeth are usually present, and tooth wear can be considered. This is not always an accurate indication, since it is largely dependent on the type of food being eaten by an individual. It is best to consider all the teeth in the population as a whole, as this will usually provide a better guide to the amount of attrition to be expected. The molar attrition charts of Miles (1963a,b) and Brothwell (1981) have been widely used in ageing of adult skeletons in recent work. The research done on the Spitalfields population suggests that this method of ageing adult skeletons is not really valid. It is possible, however, that underageing of this population was caused by the consumption of softer foods than would have been available to the earlier populations for which the charts were originally produced. There is little or no evidence on which to base such a suggestion, since there are no Anglo-Saxon or Medieval burial populations with known age and sex. The work of Cayton (1980) suggests that Anglo-Saxons were reaching a greater age than is suggested by their dental attrition, but this was based on documentary evidence and usually involved individuals from the upper echelons of that society. Lovejoy (1985) presents work on the Libben population of American Indians, suggesting that dental wear has a high correlation with age, and, if used in a multifactorial determination of age, should yield good results up to the age of around 50 years. Dental attrition may yet emerge as a valid method of age estimation, since new methods, based on the complete dentition, are being developed and tested on populations of known age (Pot, 1988; Bouts and Pot, 1989). It will, however, never be possible to prove how much wear occurred at specific ages in a Saxon or Medieval population, and a ten-year estimate is probably the best that can hoped for using this method.

Another method of ageing adults is to consider cranial suture closure. This method is less widely used now, since it has been found to be less accurate than any other visual technique (Brothwell, 1981). Work on a documented collection of Dutch crania has suggested that cranial suture closure is fairly reliable up to the age of 50, but after this there was a large number of skulls which still had open sutures (Perizonius, 1984). This would make it likely that a skull belonging to an old age group would be placed in a younger category if sutural closure was the only ageing method available. Meindl and Lovejoy (1985) suggest that the use of ectocranial suture closure is a valid method of ageing when used in conjunction with other factors, although in their test (Lovejoy, Meindl, Mensforth & Barton, 1985) its correlation with actual age was only 0.53.The occipital sphenoid suture has been found to be fairly reliable, but tends to close around the age of 21 when it is really of least use as an age determinant. The main vault sutures (coronal, sagittal and lambdoid) almost invariably close on the endocranial (interior) surface first, followed by the ectocranial side a few years later, and in the order sagittal, coronal, lambdoid. This order can usually be relied upon, and therefore suture closure can be used for a relative estimate of age, even if not an absolute one. It will give an approximate guide to the accuracy of tooth wear in younger individuals, for example (although if the individual was old and still had unfused sutures and little molar attrition, this method would not be of much help in estimating his age at death). However, Singer (in Vallois, 1960) notes that sutures can be reopened by the action of dilute acids, and this needs testing in relation to acidic soil, since it would suggest a younger age by this technique (although most skeletons from acidic soil tend to be in very poor condition anyway).

The most widely used ageing technique in forensic science, when the skeleton alone is being considered, is the changing surface of the pubic symphysis of the pelvis (Todd, 1920; McKern and Stewart, 1957; McKern, 1976; Hanihara and Suzuki, 1978; Meindl, Lovejoy, Mensforth & Walker, 1985; Katz and Suchey, 1986). The last two studies both found the Todd system to be the most accurate, and produced modified scales based on this work. However, unless a series of archaeological skeletons is very well preserved, it is unlikely that more than a few individuals will be found to have this bone intact and uneroded. In any case, this method can only be used with any reliability on male skeletons, since changes in childbirth can radically alter the pubis in females (Gilbert and McKern, 1973; Gilbert, 1973; Suchey, 1979). Suchey (1979) found the 1973 Gilbert and McKern system for the ageing of the female skeleton from the Os pubis to be highly unreliable. The accuracy of the technique for male skeletons is well attested in the forensic world for individuals under c.50 years of age, but it is difficult to use on badly eroded bones from archaeological sites, and may be different in ancient and modern specimens.

A similar problem is encountered in the use of a method for estimating age from changes in the sternal rib (Iscan et al, 1984, 1985, 1986a, 1986b). In this method, the sternal end of the rib is studied and assigned to one of nine phases related to change with age. The accuracy of this method is thought to be as good as that obtained in the use of the pubis. The fragility of the ribs, however, means that the ends, if not the whole bone, are often lost in the ground, thus making it almost impossible to use this method in the majority of archaeological populations.

Lovejoy, Meindl, Pryzbeck & Mensforth (1985), noted the higher preservation rate of the auricular surface of the ilium, and have devised a new method involving the metamorphosis of this joint facet in the determination of adult age at death. The authors claim that the technique is highly replicable, although admitting that it is ‘somewhat more difficult to apply’ than pubic symphyseal ageing, with which they compare it favourably. Unlike the pubis, changes still occur after the age of 50 years, making it a valuable tool in the estimation of age throughout adult life. Its greater preservation potential may mean that this joint will eventually prove to be more useful than the pubis in estimating age in archaeological populations. The authors do however advocate the use of as many techniques as possible in assigning ages to skeletal populations, since a multifactorial approach yields better results.

If there is an opportunity for radiological analysis, a number of methods have been established for estimating age at death from changes in the internal bone structure (e.g. Acsádi and Nemeskéri, 1970), especially of the humeral head, the femoral head and the clavicle (Walker and Lovejoy, 1985). This last study found that the clavicle was the best indicator of age in radiographic study. However, to use this method on most skeletal populations would be time-consuming and costly, and it is therefore infrequently used. It is also likely to be of little use in female skeletons since hormonal changes after the menopause mean that bone loss is not a steady phenomenon.

One other method which can be used in conjunction with the above, or alone if all else fails, is the presence or absence of signs of old age. As we get older, bony changes occur especially at the major joints, and cartilage may become ossified. Ligamentous ossification may also occur, especially on the anterior of the patella, the posterior surface of the calcaneus, and the proximal end of the ulna. Osteophytic lipping may be present on the vertebrae and the main joints, especially the hips, knees, elbows and shoulders. If the individual is affected by osteoarthritis there is probably a good chance that he was mature, although we cannot be sure that this disease did not affect our ancestors at an earlier age than is normal today. However, problems with this method include the fact that absence of these pointers does not necessarily mean that the individual was young (although it is more likely). Calcified cartilage will be one of the first things to be lost after the decay of the soft tissues, so it is only found in skeletons which are preserved in good condition. Osteoarthritis may be present on a joint secondary to another lesion, especially trauma, such as dislocation of the hip or shoulder. If this joint is the only part of the skeleton to be preserved (as is sometimes the case) it is extremely difficult to estimate the age of the individual, and an age should probably not be assigned to such a skeleton.

Such are the problems of ageing a skeleton, and it may now be realised why it is sometimes impossible to classify an individual into a smaller age range than ‘young’, ‘middle-aged’ or ‘old’. Even relatively narrow ranges such as ‘25-35’ may not appear very accurate to the archaeologist. However, it must be remembered that if such a range is given, there is no absolute guarantee that the individual in question died between those ages. It is only the most likely range into which his age at death may fall.

Stirland, at the Meeting of the Palaeopathology Assoc. in May 1989, has suggested that we should not attempt to age skeletal material more precisely than the categories young adult (20 - mid 20's), adult (late 20's - 40's) and old adult (40+), and that any estimates should be based on the entire skeleton only. Although this may be a little over cautious, it is certain that skeletal ageing techniques are not as accurate as has been assumed in the past, and it may be misleading to quote an age range of five or ten years for individuals thought to be over 25 years of age.

3.1.2. Methods applied to the Study Populations

3.1.2.1. Juveniles

The methods of ageing children at the sites considered in this study were the three major ones, i.e. the calcification and eruption stages of the teeth, the lengths of the diaphyses of the long bones and the stage of epiphyseal union. In the work both the formation and the eruption of the teeth of juveniles were considered in each dentition wherever possible. Ages estimated from the teeth were found to show a high correlation (in the Hirsel population at least, correlation coefficient = 0.98, see Fig. 3.1) with those estimated from long bone lengths, the standards for which were originally calculated using tooth *calcification* (Stloukal and Hanáková, 1978).

The histograms presented as part of Figure 3.1 show the numbers of Hirsel children in each age group aged by teeth and long bones, firstly of the children for whom age was estimated using the teeth, and then for the children aged by long bone length. The white sections of the bars in both cases includes those children for which both methods could be used (but plotted according to the age given by the method under consideration only), and the hatched sections show those children who could only be aged by one method. The distributions are similar, but there are slightly more infants aged by long bone length than by teeth. This is probably because the small tooth buds of tiny children are easily lost on excavation or by the processes of erosion.

Tables 3.1 and 3.2 show the numbers of children aged by each method at Jarrow, Monkwearmouth and The Hirsel. It should be noted that the Jarrow and Monkwearmouth figures do not include the children aged by Wells, since the methods used for particular individuals are not recorded in his work.

	Ageing Techniques			
Site	Teeth	Bones	Epiphyses	Other
JA Sax	8	6	1	1
JA Med	7	10	0	0
MK	9	15	1	1
HIR	97	97	4	0

Table 3.1

	No. of Methods			
Site	1	2	3	Total
JA Sax	12	2	0	14
JA Med	7	5	0	12
MK	13	5	1	19
HIR	39	78	1	118

Table 3.2

This suggests that the age determinations of Hirsel children are likely to be more accurate than those of the Jarrow and Monkwearmouth children, since more of the Hirsel estimates are based on two methods of ageing than on one, and on teeth as much as long bones. However, the children represented in this table are only a small sample of the children from Jarrow and Monkwearmouth, and they were in general less well preserved than those seen by Wells.

It is probably reasonable to assume that the estimated ages for the children in these populations are as accurate as possible given the condition of the remains, the time and resources available for the analysis, and the current state of research.

3.1.2.2. Adults

Age was estimated using the tooth wear charts of Brothwell (1981), occasional use of the pubic symphysis (Katz and Suchey, 1986), and visual examination of the condition of the bones was used for some attempt at confirmation. Cranial suture closure was noted for the same reason, although it is recognised that this last method is less than accurate. In most cases, although the less accurate ageing pointers were noted, the individual was aged from the most reliable techniques available, since averaging based on all the methods is likely to lead to greater inaccuracy.

Tables 3.3 and 3.4 record the numbers of each technique used in the ageing of adults from Jarrow, Monkwearmouth and the Hirsel. The adults aged by Wells are not included since methods of individual age estimations were not recorded in his notes.

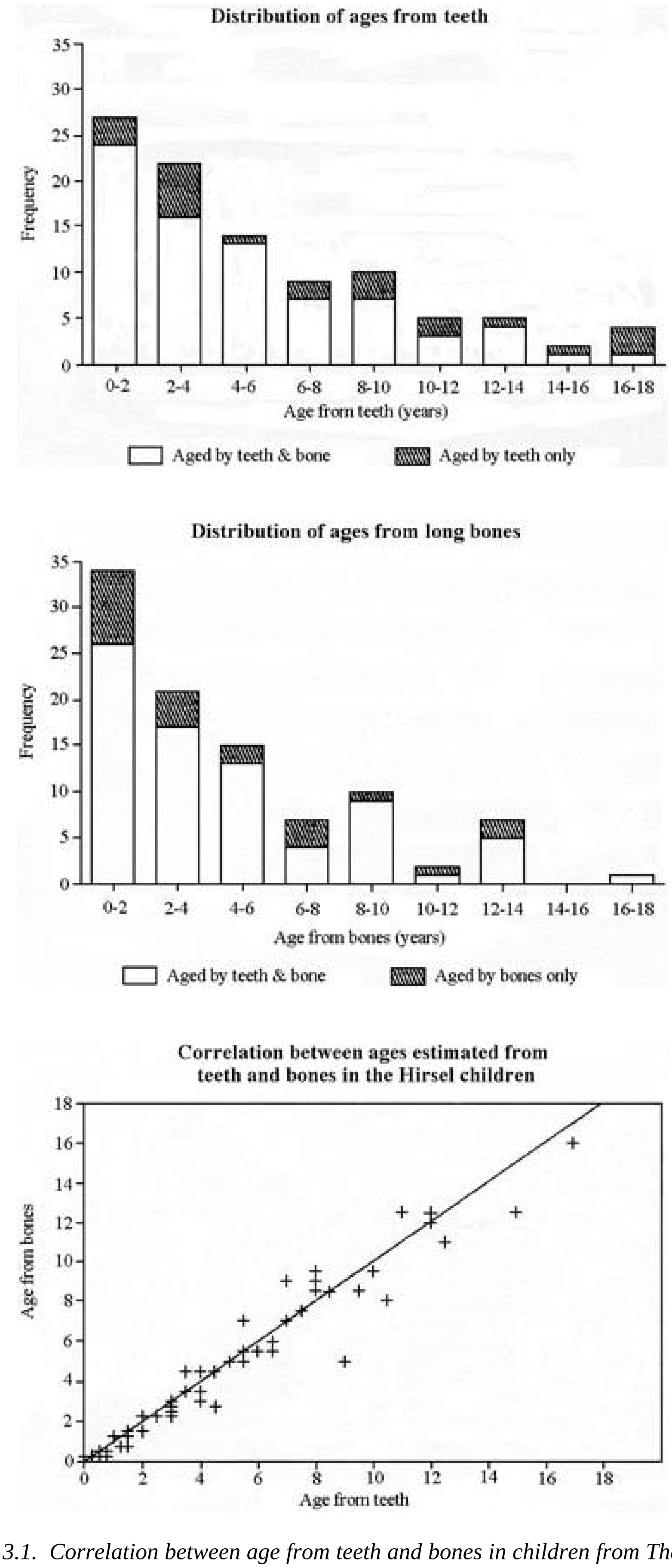


Figure 3.1. Correlation between age from teeth and bones in children from The Hirsel.

Site	Method of Ageing				
	Tooth Wear	Pubis	Bone Condition	Suture Closure	Epiphyses
JA Sax	8	1	3	5	1
JA Med	9	4	5	7	4
MK	21	3	16	12	4
HIR	130	29	73	126	26

Table 3.3

This shows that molar attrition, cranial suture closure and general condition of the bone were the most frequently used methods of ageing adults in these populations. There was no great difference between the sexes, except at The Hirsel where twice as many men as women were aged by the pubic symphysis.

Site	Number of Techniques					
	1	2	3	4	5	Total
JA Sax	4	3	1	0	1	9
JA Med	4	7	1	2	0	14
MK	16	6	5	2	0	29
HIR	25	62	45	22	2	96

Table 3.4

Most of the skeletons from The Hirsel were aged by two or more techniques, which gives the estimates slightly greater credibility. The Jarrow and Monkwearmouth figures are really too small to draw conclusions.

It is thought unlikely that the estimation of adult age at death in the populations considered here can be viewed as giving an accurate picture of mortality in Anglo-Saxon and Medieval England. The inadequacy of skeletal ageing techniques has been considered above, but such techniques have been applied to these populations because no alternative methodologies were available at the time of study.

3.1.3. Age Distribution and Palaeodemography in the Study Populations

Having explained this, it is now possible to look at some examples, and make comparisons between sites. Since all the cemetery populations considered in this study have been analysed using the same methods, and are broadly contemporaneous, it seems reasonable to assume that a valid comparison of results can be made, as long as the inaccuracy of adult age estimation is continually borne in mind. Wells' figures for Jarrow and Monkwearmouth are included in this analysis, since the populations would be too small for statistical study otherwise. Work on Jarrow (Anderson and Birkett, 1988) has shown that the results obtained by Wells and the present writer are similar.

At Jarrow, of the 380 individuals, 163, or 42.9%, were less than 18 years of age at death. At Monkwearmouth there were fewer juveniles - 116 (35.5%) out of 327 "individuals". However, it must be remembered that the burial ground at Jarrow was used over a longer period than that at Monkwearmouth, and when Jarrow is divided into the loose categories "Saxon" and "Medieval" (see Section 1), it can be seen that 73 (42.9%) juveniles belong to the Saxon period and 74 (39.2%) to the Medieval (the rest being post-medieval). The Saxon figure is still much higher than that of Monkwearmouth, but the medieval period is only slightly higher. However, the cause of this difference is unknown. It is possible that living conditions at Monkwearmouth were better, or that the children living there were better nourished or cared for. It may simply be due to different burial customs, or different use of the churchyard, or may even have occurred as the result of a single epidemic. It is impossible to say which of these, if any, may be correct from the data available.

At The Hirsel 153 (45.8%) out of 334 individuals were juvenile. This figure is slightly higher again than that of Jarrow, although whether this was due to some environmental factor or another phenomenon, or even simply due to chance given the small size of the difference, is unknown.

Table 3.5 provides a summary of the numbers and percentages of children found at each of the seven sites studied in this work.

Site	No. of Individuals	No. of Children	% of Children
The Hirsel	334	153	45.8
Jarrow (Sax)	170	73	42.9
Jarrow (Med)	189	74	39.2
Monkwearmouth	327	116	35.5
Norton	126	34	27.0
Blackgate	140	36	25.7
Guisborough	47	7	14.9
Blackfriars	36	3	8.3

Table 3.5

The low proportions of children at Norton, Blackgate, Guisborough and Blackfriars are suggestive of a biasing factor. Possible causes include lack of preservation of fragile child skeletons, differential burial practices, or lower child mortality. This last is the least likely, particulary at the two earlier sites (Norton and Blackgate). Blackfriars and Guisborough were probably prestigious burial grounds and this would account for the small numbers of juveniles buried there.

The average age at death (calculated from the medians of age ranges) of the children at Monkwearmouth was 4.2 years, whereas for the Jarrow Saxon children it was nearer 7 years. The medieval juveniles at Jarrow had a slightly lower average age of 5.5 years. At The Hirsel the figure was 4.5 years. The distribution of juvenile ages at death for each site is shown in Fig. 3.2. The pie charts show the greatest similarity between distributions at The Hirsel and Saxon Jarrow.

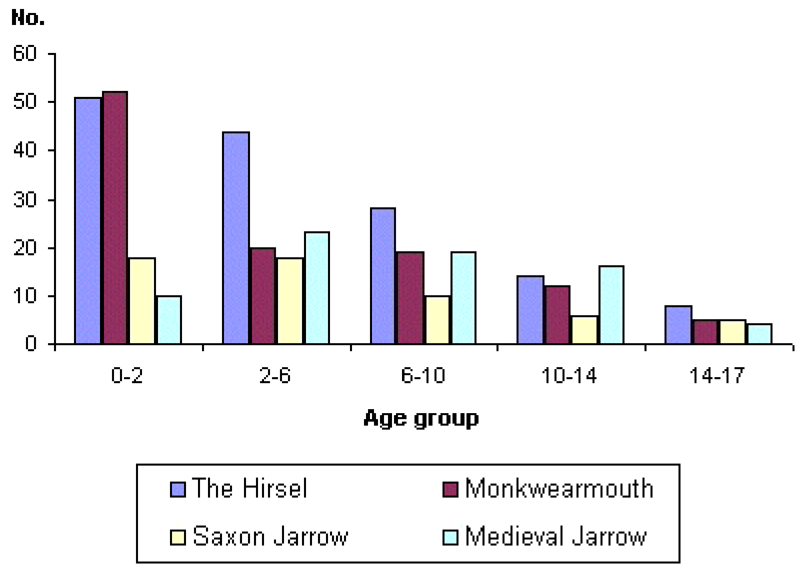
Monkwearmouth also has a similar distribution. Medieval Jarrow shows the most difference, which is probably not surprising, since the other groups are of a more similar time period, although The Hirsel dates from the 11th-15th centuries and covers both periods. It may have had a more backward community, however, since it was more rural than either Jarrow or Monkwearmouth, and might therefore present a similar picture to urban Saxon sites. Table 3.6 records the actual figures in each age group for all the sites in this study. The percentages in the 'Total' column are proportions of aged children out of the total population.

Site	0-2	2-6	6-10	10-14	14-17	Total
HIR n	51	44	28	14	8	145
%	35.2	30.3	19.3	9.6	5.5	43.4
JA n	18	18	10	6	5	57
Sax %	31.6	31.6	17.5	10.5	8.8	33.5
JA n	10	23	19	16	4	72
Med %	13.9	31.9	26.4	22.2	5.6	38.1
MK n	52	20	19	12	5	108
%	48.1	18.5	17.6	11.1	4.6	33.0
NEM n	4	3	12	8	6	33
%	12.1	9.1	36.4	24.2	18.2	26.2
BG n	11	9	7	5	4	36
%	30.6	25.0	19.4	13.9	11.1	25.7
GP n	3	2	0	2	0	7
%	42.9	28.6	-	28.6	-	14.9
BF n	1	0	1	1	0	3
%	33.3	-	33.3	33.3	-	8.3

Table 3.6

The last four sites have too few juveniles to be included in the statistical and palaeodemographic analyses.

The distribution of deaths below the age of two years is shown in Table 3.7. The totals are slightly lower than the figures given for the 0-2 age group in the previous table, because in some cases it was impossible to age these children more closely than 'infant'. The percentages in the 'Total' column show the proportions of aged infants to the rest of the juveniles.



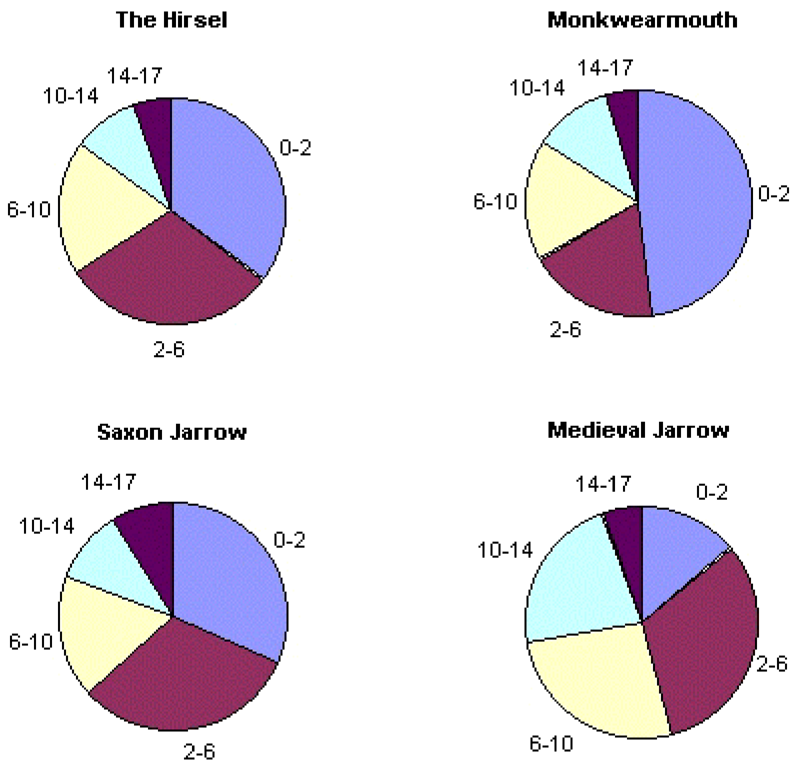


Figure 3.2. Bar and pie charts of actual numbers and percentages of children by age group.

Site	<1m	<6m	<12m	<18m	<24m	Total
HIR n %	12 25.0	12 25.0	8 16.7	12 25.0	4 8.3	48 31.4
JA n Sax %	5 27.8	4 22.2	7 38.9	0 -	2 11.1	18 24.7
JA n Med %	2 22.2	2 22.2	3 33.3	0 -	2 22.2	9 12.2
MK n %	20 17.2	14 12.1	5 4.3	2 1.7	8 6.9	49 42.2

Table 3.7

It can be seen from this that the largest proportion of infants were buried at Monkwearmouth, followed by The Hirsel, Saxon Jarrow and finally Medieval Jarrow. This would suggest that babies were healthier at Jarrow than Monkwearmouth or the Hirsel, although again the figures may be due to different burial practices (i.e. whether there was a designated area of the cemetery for infants), or even differential preservation between the two sites.

At The Hirsel, infant mortality was fairly evenly spread between newborn and 18 months. At Jarrow the greatest mortality appears to have occurred when the children reached the age of one year. At Monkwearmouth the greatest frequency of infant death was around the time of birth. This suggests that different factors were involved in the determination of infant mortality at the three sites. Perhaps at Monkwearmouth the mothers were less healthy, and consequently the babies tended to die most often soon after birth. At Jarrow, the most frequently occurring deaths at the end of the first year of life could be accounted for by some form of infection. The Hirsel figures would suggest generally poor health when compared with the other populations, but the percentage of infant mortality in the whole juvenile population was less than that at Monkwearmouth. It is difficult to know the true reasons for the differences in spread of infant deaths at these populations, especially as they occurred over a number of centuries. Chance may be an important factor, especially in the excavation process, but illness and malnutrition cannot be ignored as possible causes.

An average age at death was not calculated for the adult skeletons, since the results obtained are felt to be misleading due to the anticipated underageing of a fair proportion of the adult individuals. The percentages of adults in each age group from all the sites are presented as pie charts in Fig. 3.3. The pie charts show that there is most similarity between Monkwearmouth and Jarrow, and that Guisborough and The Hirsel are also fairly similar in adult age distribution.

Life tables (Figs. 3.4-3.8) have been calculated for each of the three larger populations in this study. The smaller populations were not used due to the small proportions of child remains, and in the cases of Blackfriars and Guisborough, due to small sample size. Some of the problems of using these tables with skeletal data have been considered in the introduction to this chapter. However, the large sample sizes of the populations from Jarrow, Monkwearmouth and the Hirsel, and the large proportion of children at each, means that fewer assumptions have to be made in the construction and analysis of the life tables based on them.

Life tables have been calculated, as stated above (in the introductory section of this chapter), both for the estimated age distributions as calculated from the study of the skeletal remains and for the weighted adult ages on the assumption that half of each age group was underaged by ten years. The results of e(x) (life expectancy), l(x) (survivorship) and q(x) (crude probability of death, after Boddington 1982) were plotted against age in each case (Figs. 3.9-3.11). The curves obtained for the two sets of data do not seem to differ greatly. Life expectancy is slightly higher throughout life, which is not really surprising since the weighted figures assume a maximum age of 70 years rather than 60. The difference is at most one of five years, but the general appearance of the curve changes very little. The probability of dying is slightly reduced , most noticeably at age 17, but otherwise both this and the graph of survivorship are little altered. These results seem to indicate that conclusions made on the basis of life table calculations are likely to be generally correct, at least in these three major fields of data. It is obvious, however, that if the assumption of 50% individuals underaged is invalid and the various age groups show markedly different proportions of individuals wrongly aged, that the curve obtained will not be quite so similar to the original. The testing of this in full will unfortunately have to await the results of the analysis of a known population with consistent under- or over-ageing of adult individuals.

The estimation of population size at each of the sites is based on a standard formula (Boddington, 1982), and has been corrected to include those individuals who were present in the skeletal remains but who could not be aged with enough accuracy to be included in the life table. In every case the population size given is likely to be greatly underestimated, partly due to the fact that it has been impossible to look at complete populations. At all three sites the excavation of the entire burial ground was not possible, although at The Hirsel it is likely that the vast majority

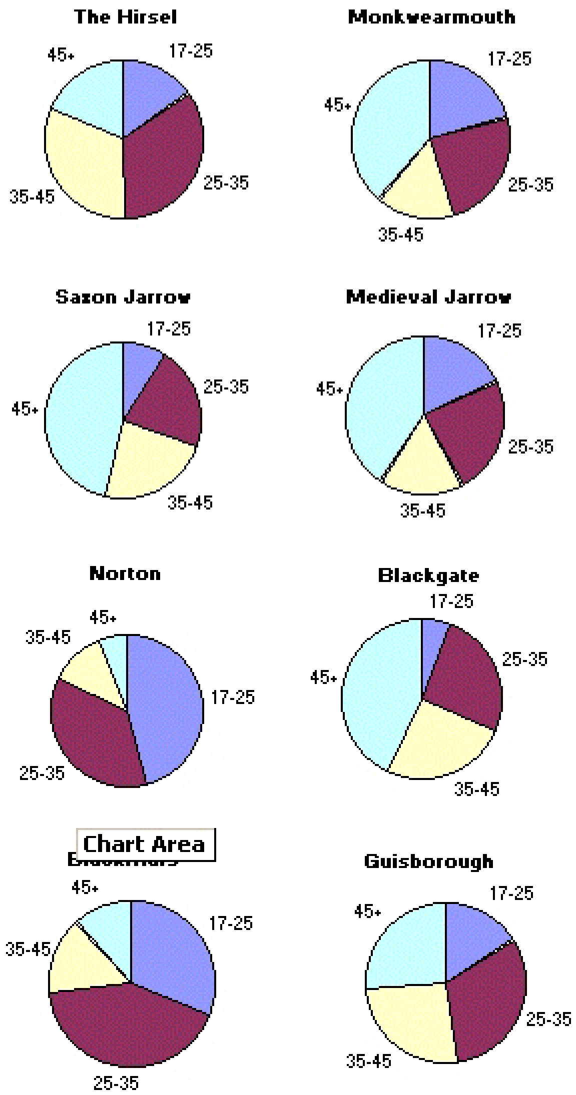


Figure 3.3. Pie charts of percentage age distribution of adults at each site.

Number of individuals: 307 (91.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	51	16.6	100.0	183.4	2141.0	0.17	0.083	21.4	8.6
2	44	14.3	83.4	304.9	1957.7	0.17	0.043	23.5	14.2
6	28	9.1	69.1	258.0	1652.8	0.13	0.033	23.9	12.0
10	14	4.6	59.9	230.6	1394.8	0.08	0.019	23.3	10.8
14	8	2.6	55.4	162.2	1164.2	0.05	0.016	21.0	7.6
17	25	8.1	52.8	389.6	1002.0	0.15	0.019	19.0	18.2
25	55	17.9	44.6	356.7	612.4	0.40	0.040	13.7	16.7
35	52	16.9	26.7	182.4	255.7	0.63	0.063	9.6	8.5
45	30	9.8	9.8	73.3	73.3	1.00	0.067	7.5	3.4

Estimated maximum age: 60 years

Crude Mortality Rate: 46.71

Estimated length of cemetery use: 200 years

Estimated population size: 33
(Corrected for total excavated remains: 36)

Weighted adult ages
Number of individuals: 307 (91.9% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	51	16.6	100.0	183.4	2385.5	0.17	0.083	23.9	7.7
2	44	14.3	83.4	304.9	22.2.1	0.17	0.043	26.4	12.8
6	28	9.1	69.1	258.0	1897.2	0.13	0.033	27.5	10.8
10	14	4.6	59.9	230.6	1639.3	0.08	0.019	27.4	9.7
14	8	2.6	55.4	162.2	1408.6	0.05	0.016	25.4	6.8
17	25	4.2	52.8	405.2	1246.4	0.08	0.010	23.6	17.0
25	40	13.0	48.5	420.2	841.2	0.27	0.027	17.3	17.6
35	53	17.3	35.5	268.7	421.0	0.49	0.049	11.9	11.3
45	41	13.4	18.2	115.6	152.3	0.73	0.073	8.3	4.8
55	15	4.9	4.9	36.6	36.6	1.00	0.067	7.5	1.5

Estimated maximum age: 70 years

Crude Mortality Rate: 41.92

Estimated length of cemetery use: 200 years

Estimated population size: 37
(Corrected for total excavated remains: 40)

Figure 3.4. Life Tables: The Hirsel.

Number of individuals: 190 (58.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	52	27.4	100.0	172.6	1927.6	0.27	0.137	19.3	9.0
2	20	10.5	72.6	269.5	1755.0	0.14	0.036	24.2	14.0
6	19	10.0	62.1	228.4	1485.5	0.16	0.040	23.9	11.8
10	12	6.3	52.1	195.8	1257.1	0.12	0.030	24.1	10.2
14	5	2.6	45.8	133.4	1061.3	0.06	0.019	23.2	6.9
17	17	8.9	43.2	309.5	927.9	0.21	0.026	21.5	16.1
25	20	10.5	34.2	289.5	618.4	0.31	0.031	18.1	15.0
35	13	6.8	23.7	202.6	328.9	0.29	0.029	13.9	10.5
45	32	16.8	16.8	126.3	126.3	1.00	0.067	7.5	6.6

Estimated maximum age: 60 years

Crude Mortality Rate: 51.88

Estimated length of cemetery use: 300 years

Estimated population size: 12
(Corrected for total excavated remains: 21)

Weighted adult ages
Number of individuals: 190 (58.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	52	27.4	100.0	172.6	2112.9	0.27	0.137	21.1	8.2
2	20	10.5	72.6	269.5	1940.3	0.14	0.036	26.7	12.8
6	19	10.0	62.1	228.4	1670.8	0.16	0.040	26.9	10.8
10	12	6.3	52.1	195.8	1442.4	0.12	0.030	27.7	9.3
14	5	2.6	45.8	133.4	1246.6	0.06	0.019	27.2	6.3
17	9	4.7	43.2	326.3	1113.2	0.11	0.014	25.8	15.4
25	18	9.5	38.4	336.8	786.8	0.25	0.025	20.5	15.9
35	17	8.9	28.9	244.7	450.0	0.31	0.031	15.5	11.6
45	22	11.6	20.0	142.1	205.3	0.58	0.058	10.3	6.7
55	16	8.4	8.4	63.2	63.2	0.67	0.067	7.5	3.0

Estimated maximum age: 70 years

Crude Mortality Rate: 47.33

Estimated length of cemetery use: 300 years

Estimated population size: 13
(Corrected for total excavated remains: 23)

Figure 3.5. Life Tables: Monkwearmouth.

Number of individuals: 100 (40.2% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	18	18.0	100.0	182.0	2123.5	0.18	0.090	21.2	8.6
2	18	18.0	82.0	292.0	1941.5	0.22	0.055	23.7	13.8
6	10	10.0	64.0	236.0	1649.5	0.16	0.039	25.8	11.1
10	6	6.0	54.0	204.0	1413.5	0.11	0.028	26.2	9.6
14	5	5.0	48.0	136.5	1209.5	0.10	0.035	25.5	6.4
17	4	4.0	43.0	328.0	1073.0	0.09	0.012	25.0	15.4
25	9	9.0	39.0	345.0	745.0	0.23	0.023	19.1	16.2
35	10	10.0	30.0	250.0	400.0	0.33	0.033	13.3	11.8
45	20	20.0	20.0	150.0	150.0	1.00	0.067	7.5	7.1

Estimated maximum age: 60 years

Crude Mortality Rate: 47.09

Estimated length of cemetery use: 300 years

Estimated population size: 7
(Corrected for total excavated remains: 18)

Weighted adult ages
Number of individuals: 100 (40.2% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	q̄(x)	e(x)	C(X)
0	18	18.0	100.0	182.0	2306.5	0.18	0.090	23.1	7.9
2	18	18.0	82.0	292.0	2124.5	0.22	0.055	25.9	12.7
6	10	10.0	64.0	236.0	1832.5	0.16	0.039	28.6	10.2
10	6	6.0	54.0	204.0	1596.5	0.11	0.028	29.6	8.8
14	5	5.0	48.0	136.5	1392.5	0.10	0.035	29.0	5.9
17	2	2.0	43.0	336.0	1256.0	0.05	0.006	29.2	14.6
25	7	7.0	41.0	375.0	920.0	0.17	0.017	22.4	16.3
35	9	9.0	34.0	295.0	545.0	0.26	0.026	16.0	12.8
45	15	15.0	25.0	175.0	250.0	0.60	0.060	10.0	7.6
55	10	10.0	10.0	75.0	75.0	1.00	0.067	7.5	3.3

Estimated maximum age: 70 years

Crude Mortality Rate: 43.36

Estimated length of cemetery use: 300 years

Estimated population size: 8
(Corrected for total excavated remains: 19)

Figure 3.6. Life Tables: Saxon Jarrow.

Number of individuals: 148 (57.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}(x)$	e(x)	C(X)
0	10	6.8	100.0	193.2	2357.8	0.07	0.034	23.6	8.2
2	23	15.5	93.2	341.9	2164.5	0.17	0.042	23.2	14.5
6	19	12.8	77.7	285.1	1822.6	0.17	0.041	23.5	12.1
10	16	10.8	64.9	237.8	1537.5	0.17	0.042	23.7	10.1
14	4	2.7	54.1	158.1	1299.7	0.05	0.017	24.0	6.7
17	14	9.5	51.4	373.0	1141.6	0.18	0.023	22.2	15.8
25	18	12.2	41.9	358.1	768.6	0.29	0.029	18.3	15.2
35	13	8.8	29.7	253.4	410.5	0.30	0.030	13.8	10.7
45	31	20.9	20.9	157.1	157.1	1.00	0.067	7.5	6.7

Estimated maximum age: 60 years

Crude Mortality Rate: 42.41

Estimated length of cemetery use: 500 years

Estimated population size: 7
(Corrected for total excavated remains: 12)

Weighted adult ages
Number of individuals: 148 (57.1% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	$\bar{q}(x)$	e(x)	C(X)
0	10	6.8	100.0	193.2	2584.5	0.07	0.034	25.8	7.5
2	23	15.5	93.2	341.9	2391.2	0.17	0.042	25.6	13.2
6	19	12.8	77.7	285.1	2049.3	0.17	0.041	26.4	11.0
10	16	10.8	64.9	237.8	1764.2	0.17	0.042	27.2	9.2
14	4	2.7	54.1	158.1	1526.4	0.05	0.017	28.2	6.1
17	7	4.7	51.4	391.9	1368.2	0.09	0.012	26.6	15.2
25	16	10.8	46.6	412.2	976.4	0.23	0.023	20.9	15.9
35	16	10.8	35.8	304.1	564.2	0.30	0.030	15.8	11.8
45	21	14.2	25.0	179.1	260.1	0.57	0.057	10.4	6.9
55	16	10.8	10.8	81.1	81.1	1.00	0.067	7.5	3.1

Estimated maximum age: 70 years

Crude Mortality Rate: 38.69

Estimated length of cemetery use: 500 years

Estimated population size: 8
(Corrected for total excavated remains: 13)

Figure 3.7. Life Tables: Medieval Jarrow.

Number of individuals: 248 (48.8% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	28	11.3	100.0	188.7	2263.3	0.11	0.056	22.6	8.3
2	41	16.5	88.7	321.8	2074.6	0.19	0.047	23.4	14.2
6	29	11.7	72.2	265.3	1752.8	0.16	0.041	24.3	11.7
10	22	8.9	60.5	224.2	1487.5	0.15	0.037	24.6	9.9
14	9	3.6	51.6	149.4	1263.3	0.07	0.023	24.5	6.6
17	18	7.3	48.0	354.8	1113.9	0.15	0.019	23.2	15.7
25	27	10.9	40.7	352.8	759.1	0.27	0.027	18.6	15.6
35	23	9.3	29.8	252.0	406.3	0.31	0.031	13.6	11.1
45	51	20.6	20.6	154.2	154.2	1.00	0.067	7.5	6.8

Estimated maximum age: 60 years

Crude Mortality Rate: 44.18

Estimated length of cemetery use: 700 years

Estimated population size: 8
(Corrected for total excavated remains: 16)

Weighted adult ages
Number of individuals: 248 (48.8% of Total Excavated Individuals)

Age	D(X)	d(X)	l(x)	L(X)	T(x)	q(X)	ꝗ(x)	e(x)	C(X)
0	28	11.3	100.0	188.7	2472.4	0.11	0.056	24.7	7.6
2	41	16.5	88.7	321.8	2283.7	0.19	0.047	25.7	13.0
6	29	11.7	72.2	265.3	1961.9	0.16	0.041	27.2	10.7
10	22	8.9	60.5	224.2	1696.6	0.15	0.037	28.1	9.1
14	9	3.6	51.6	149.4	1472.4	0.07	0.023	28.5	6.0
17	9	3.6	48.0	369.4	1323.0	0.08	0.009	27.6	14.9
25	23	9.3	44.4	397.2	953.6	0.21	0.021	21.5	16.1
35	25	10.1	35.1	300.4	556.5	0.29	0.029	15.9	12.2
45	36	14.5	25.0	177.4	256.0	0.58	0.058	10.2	7.2
55	26	10.5	10.5	78.6	78.6	1.00	0.067	7.5	3.2

Estimated maximum age: 70 years

Crude Mortality Rate: 40.45

Estimated length of cemetery use: 700 years

Estimated population size: 9
(Corrected for total excavated remains: 18)

Figure 3.8. Life Tables: Saxon and Medieval Jarrow.

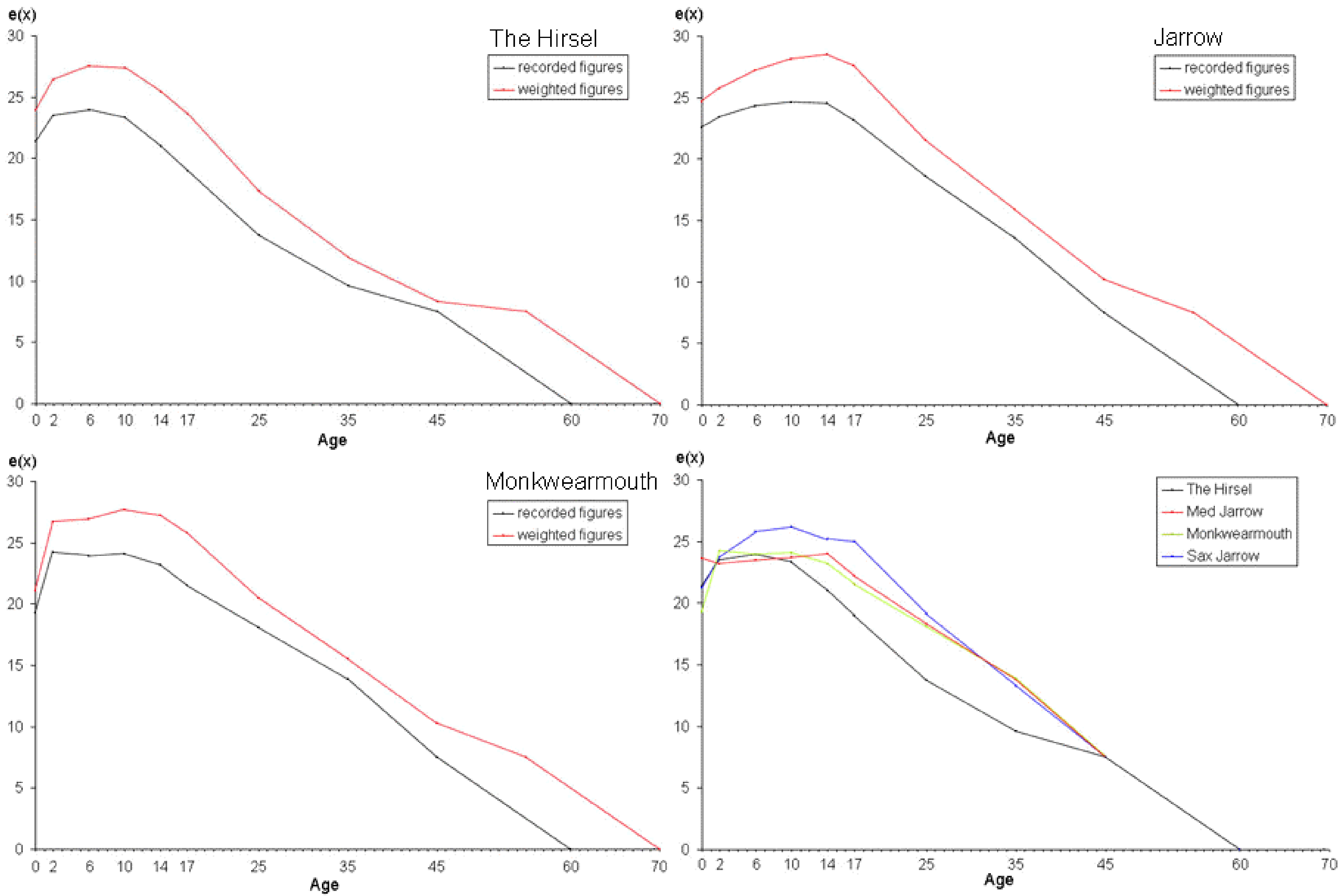


Figure 3.9. Graphs of life expectation.

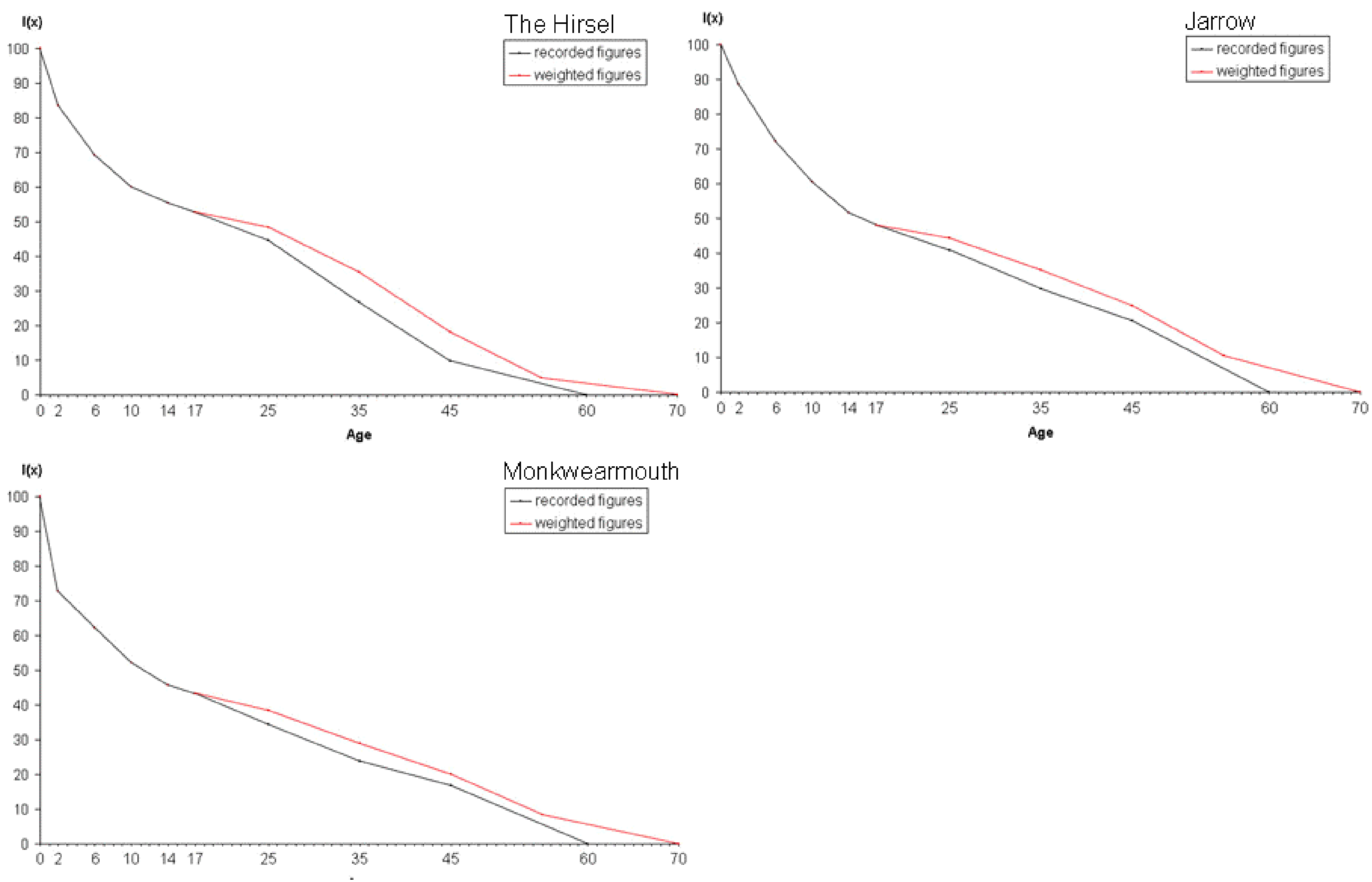


Figure 3.10. Survivorship curves.

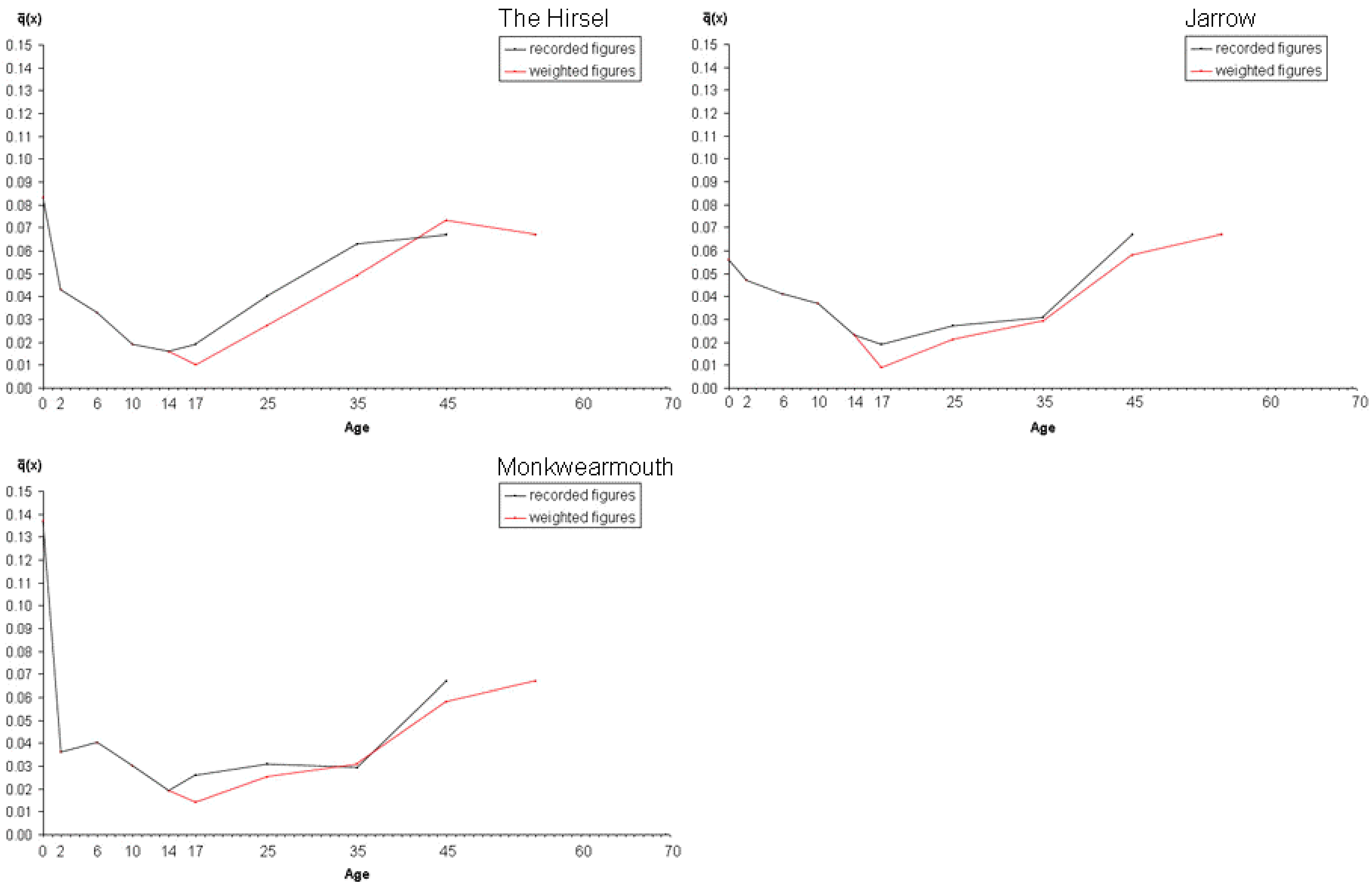


Figure 3.11. Graphs of crude probability of death.

of individuals originally buried were recovered. Other factors which may affect the population represented in the cemetery are not taken into account by the population estimation statistic, including burial at another site and loss of skeletal remains for various reasons (see Section 2.3). The figure given should therefore be seen as the absolute minimum number of individuals required to sustain the *cemetery* population at its estimated level.

The life tables and graphs of the three populations will now be considered in more detail. The figures for Jarrow are given for the two time periods separately and combined, but are graphed on the combined figures. This assumes an even spread of use of the cemetery throughout its functional life, which makes it more comparable with the other two sites. The life expectancy at birth is higher at Medieval Jarrow than in the other groups, but at age 2 it is highest at Monkwearmouth. Life expectancy is in general fairly similar throughout the groups, however, with the exception of The Hirsel, where it starts to reduce in an earlier age group (17-25 as opposed to 25-35).

The survivorship curves are all broadly similar, although the percentage survival at Jarrow at age 45 is somewhat higher than at The Hirsel. The crude probability of death curves show the greatest divergence between the groups, with the greatest probability of death in infancy at both The Hirsel and Monkwearmouth, but at age 45 at Jarrow. The difference is due to the smaller percentage of infants in the medieval period at Jarrow, possible reasons for which were discussed above.

Fig. 3.12 presents the data for the distribution of age at death (D(X)) in the three populations. From these histograms it can be seen that of the adults more people survived past middle-age than the proportion dying young at both Jarrow and Monkwearmouth. At The Hirsel a larger proportion died in middle age. Assuming that the Hirsel individuals were not underaged due to different tooth wear patterns, or that the patterns are not at variance due to the different methods used by the present author at The Hirsel and by Wells at Jarrow and Monkwearmouth (both of which are possibilities), this suggests some form of environmental influence affecting individuals who reached the age of around 30. Wells suggests in the Jarrow report (forthcoming) that monastic life could help in providing high nutritional standards at Monkwearmouth and Jarrow. He says ‘Perhaps the example of an industrious and beneficent abbey served to inspire a high level of husbandry in the surrounding villages. Perhaps the proximity of the sea offered unusual (and most essential) protein ration with fish, molluscs and various kelps’.

Fig. 3.13 shows the percentages of each age group at the three main sites in bar chart form for ease of comparison. The general distribution obtained is similar to the histograms. The picture for each group is fairly similar, with most deaths occurring at 0-2 years and 45+, although at Medieval Jarrow the pattern is changed to 2-6 and 45+, and at the Hirsel it is 0-2 and 25-35 years.

Although in some populations a bias is found with respect to the lack of infant and child burials, when a life table is constructed there may be some bias in the opposite direction due to the greater ease of assigning an age at death to juvenile skeletons, even those in comparatively poor condition. Boddington (1982) found that the greater the proportion of unaged adult burials, the greater the effect on the calculated expectancy of life at birth (e(0)). Figure 3.14 shows the proportions of aged and unaged adult burials at The Hirsel, Monkwearmouth and Jarrow. Table 3.8 shows the numbers and percentages of unaged adult and child burials for comparison. It can be seen from this that The Hirsel is likely to be the population least affected by biasing. The large proportion of unaged Monkwearmouth adults is due to the poor preservation of skeletal material at that site, and a similar problem is apparent at Saxon Jarrow. Boddington suggests that such biasing can underestimate e(0) by as much as 5 years, and this is in addition to any effect that inaccuracy of adult ageing may have had. However, the estimation of maximum age in the population can also have an effect on e(0) and it is possible that the increase in e(0) seen in the weighted figures is due to the increase of maximum age from 60 to 70 years.

	Adults			Children		
Site	No.	Unaged	%	No.	Unaged	%
HIR	181	19	10.5	153	8	5.2
MK	211	129	61.1	116	8	6.9
JA Sax	97	54	55.7	73	16	21.9
JA Med	115	39	33.9	74	2	2.7
JA Both	212	93	43.9	147	18	12.2

Table 3.8

In conclusion, it can be said that the closest of the three populations, as far as age is concerned, were Monkwearmouth and Saxon Jarrow, as might be expected (especially as they were both aged by Wells). However, none of the populations were greatly different from other contemporary sites in different parts of the country. The adult figures from North Elmham, Norfolk (Wells, 1980b), for example, are very similar. Early populations had a much larger proportion of juvenile deaths than at present. This is not surprising when the poor standard of living (compared with our own) and the lack of modern medical knowledge are taken into account.

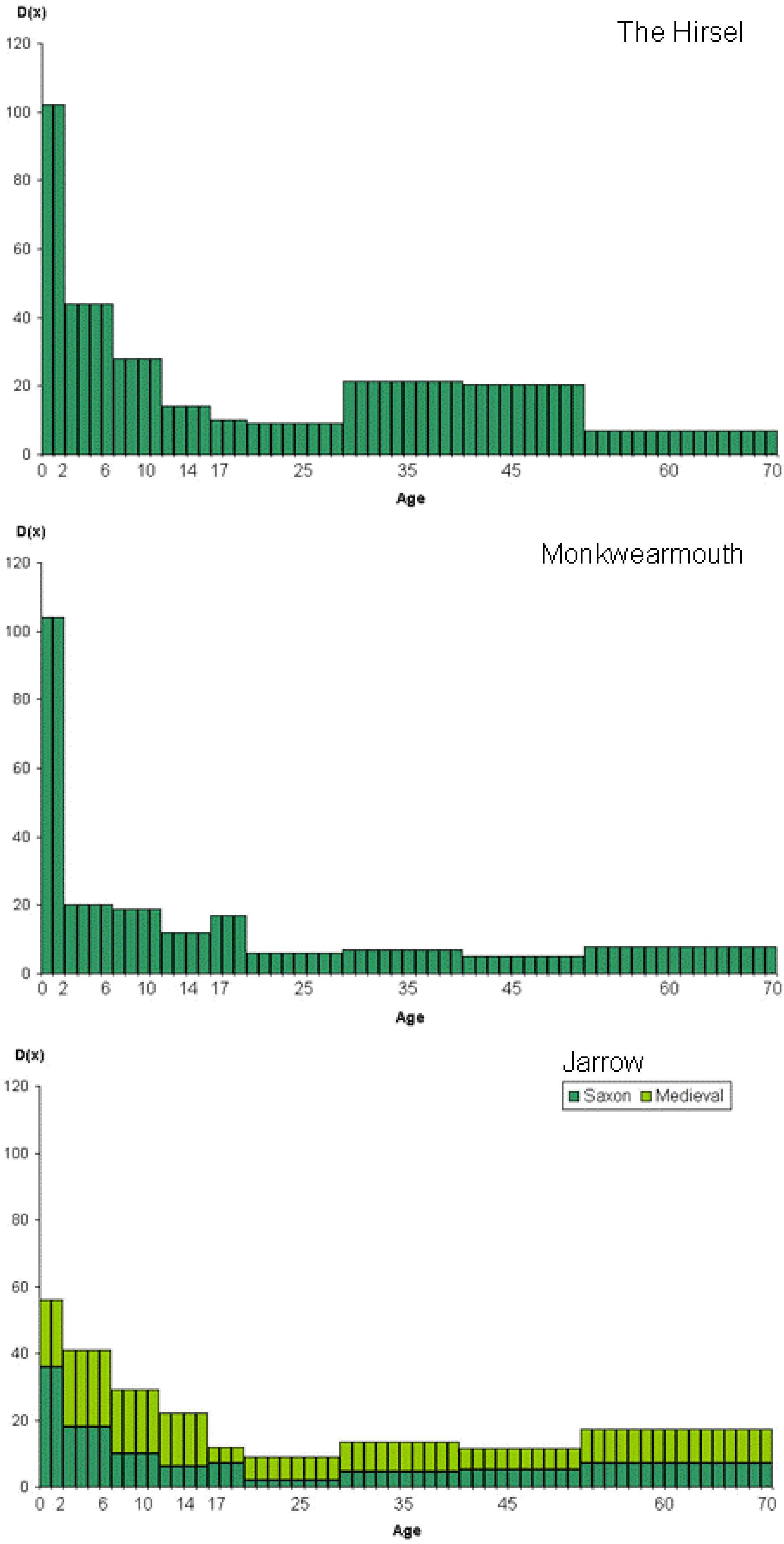


Figure 3.12. Histograms of distribution of age at death.

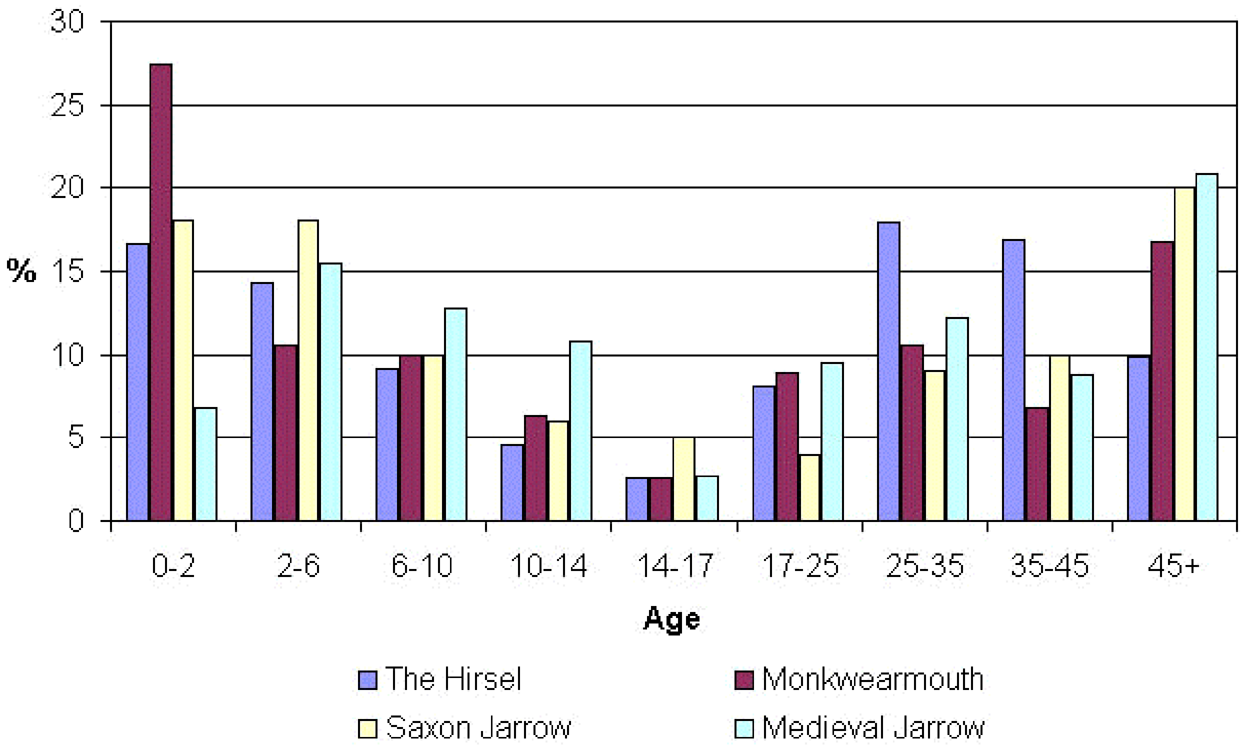


Figure 3.13. Percentages of age groups at main sites.

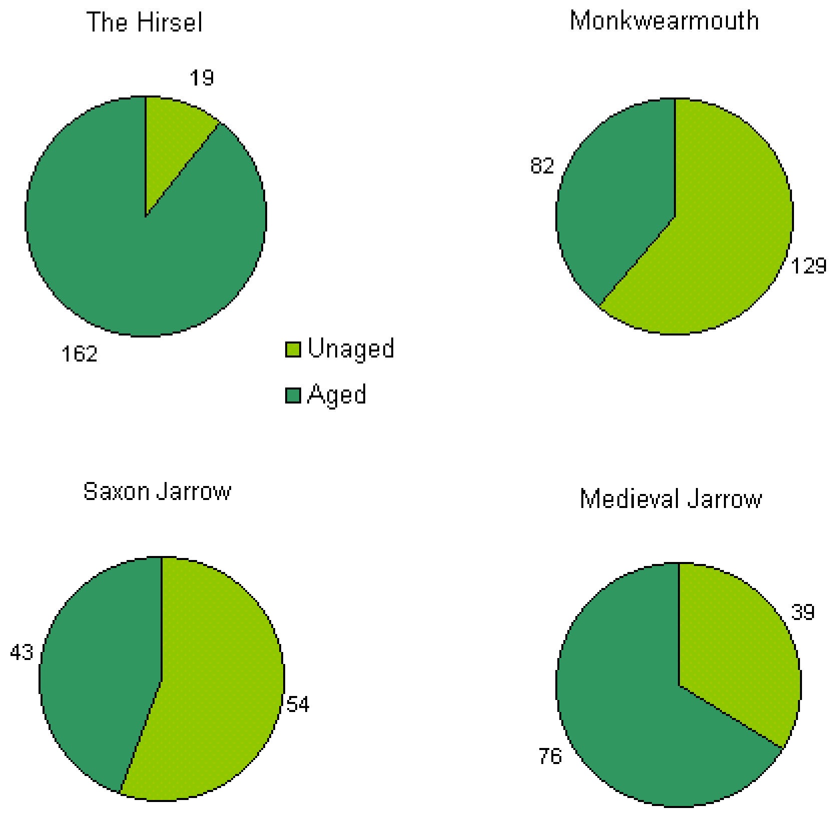


Figure 3.14. Proportions of aged and unaged adults.