Paleodemographic Comparison of a Catastrophic and an Attritional Death Assemblage

Beverley J. Margerison and Christopher J. Knüsel*

Department of Archaeological Sciences, University of Bradford, Bradford, West Yorkshire BD7 1DP, UK

KEY WORDS Black Death; plague; epidemic; Royal Mint; St. Helen-on-the-Walls; medieval

ABSTRACT The aim of this contribution is to examine the effect of an indiscriminate epidemic on a population to assess whether or not a catastrophic event can be identified from examination of paleodemographic data. Using paleodemographic techniques, the death assemblage from the Royal Mint site, London, a Black Death cemetery dated 1349 AD, is compared with that from St. Helen-on-the-Walls, York, which dates from the twelfth to the sixteenth centuries AD. The Royal Mint site represents a catastrophic cemetery, while that of St. Helen-on-the-Walls is of an attritional type. Certain features of the paleodemographic profile of the plague victims suggest that the population had been affected by factors other than natural wastage. Three factors are proposed which may define an indiscriminate catastrophic event in preindustrial populations. Am J Phys Anthropol 119:134–143, 2002. © 2002 Wiley-Liss, Inc.

This study compares the population structure of two contrasting types of cemetery (“catastrophic” and “attritional”) from archeologically derived skeletal material. Using paleodemographic techniques, it assesses the effect of an epidemic on the paleodemographic profile of a population. In order to assess the impact of a mass mortality, comparisons are drawn between the mortality profile derived from a plague burial cemetery and that from natural attrition, using medieval skeletal populations. In addition, medieval plague mortality is compared to the mortality expected from the medieval period, which is similar to the mortality expected from preindustrial societies based on data derived from the model life tables of Weiss (1973). One of the cemeteries examined in this research, the Royal Mint site, dates from the time of the Black Death in the mid-fourteenth century AD. The other cemetery, St. Helen-on-the-Walls, in York, was in use from the late twelfth century to AD 1550.

The opportunity to study actual skeletal remains from a cemetery in Britain known to be associated with the Black Death is unique. Very few plague (or other epidemic) cemeteries from any country or date have been excavated and, as there is also comparatively little demographic evidence from this period, archeological evidence is of great assistance in understanding this turbulent period. Most research on the effects of plague has concentrated on the seventeenth-century outbreaks because a greater number of mortality records and documentary evidence exist. These later outbreaks are, however, of limited use because it is conceivable that the population had acquired some immunity from exposure to plague in previous outbreaks. This study concentrates on the mortality produced in a population that had no previous exposure to plague.

AIMS AND EXPECTATIONS The archeological evidence from the Royal Mint site, i.e., the trenches and piled inhumations of thousands of individuals, suggests that the population had been affected by a catastrophe of some description. Examples of catastrophes are war, massacre, disease, and famine, and each may leave different identifying features on the resulting skeletal population. Documentary evidence tells us that this was the site of a Black Death cemetery (Hawkins, 1990). This study aims to assess whether or not the passage of an epidemic disease can be identified from the demography of the population alone, if the archeological, historical, and documentary evidence are absent. If so, the resulting paleodemographic profile could be used to assess mass graves from other periods of prehistory and history lacking documentary evidence.

Epidemics strike swiftly and lethally and, while they are highly unlikely to leave any pathognomonic

Grant sponsor: Science and Engineering Research Council, UK.

*Correspondence to: Dr. C.J. Knüsel, Calvin Wells Laboratory, Department of Archaeological Sciences, University of Bradford, Bradford, West Yorkshire BD7 1DP, UK.
E-mail: c.knusel@bradford.ac.uk

Received 3 January 2000; accepted 27 December 2001.
DOI 10.1002/ajpa.10082 Published online in Wiley InterScience (www.interscience.wiley.com).
lesions on the skeleton, their individual epidemiology may result in differences in the demographic profile of skeletal populations. If the archeological context were unknown, then would it be possible to identify 1) that the population had been affected by an epidemic, and 2) what the disease was by an examination of the demographic characteristics of the population alone? While certain epidemic diseases are known to target certain age groups, plague is reputed to be indiscriminate with regard to age or sex (Pollitzer, 1954, pp. 503, 517). The following analyses are directed to assessing these questions.

THE BLACK DEATH IN HISTORICAL CONTEXT

From its arrival in Sicily in October 1347 AD, the Black Death spread rapidly and lethally throughout Europe during the next 3 years. The majority of Europe is thought to have suffered on average between 25–50% mortality (Horrox, 1994, p. 3; Sloan, 1981). The plague met a population already weakened by wars, poor harvests, overpopulation, mur- rains (a plague-like disease in cattle), and malnutrition (Ziegler, 1969, p. 35; Campbell, 1991). The Black Death entered England via the port of Melcombe (now part of Weymouth) in Dorset in June 1348 AD (Ziegler, 1969, p. 120; Horrox, 1994, p. 63). By November, London was experiencing its first cases, but the full force did not strike the city until February 1349 AD (Horrox, 1994, p. 65). The worst period lasted for 3 or 4 months, but almost 2 years passed between the first and last fatalities (Ziegler, 1969, p. 157).

Three types of plague have been identified, each with a different mode of transmission and different symptoms. Although they did not understand the mechanisms, the medical practitioners of the time were able to identify different combinations of symptoms (Horrox, 1994, p. 4). The most familiar type is the bubonic variety, with an incubation period of less than 6 days (Pollitzer, 1954, p. 410). This is transmitted from flea to human, and is the least infectious of the three varieties. Death usually occurs within the third to the fifth day. Bubonic plague had a mortality rate of about 60–90% in India and China at the end of the nineteenth century (Pollitzer, 1954, p. 418), making it the least fatal of the three plague types.

The second variety is primary pneumonic, or pulmonary, plague (Pollitzer, 1954). This is transmitted from human to human with an incubation period from a few hours to about 2–3 days and, in rare cases, up to 6 days (Pollitzer, 1954, p. 410). It is usually transferred from a patient with bubonic plague who manifests secondary lung involvement. It is highly infectious, and it is extremely unusual for a patient to survive for longer than 2–4 days. The mortality rate is almost 100% if the patient is untreated (Twigg, 1984, p. 20).

The third type is septiemic plague. This occurs if large numbers of bacteria get into the bloodstream and overwhelm the body before the localizing effect of the lymph nodes can intervene. An infected individual may show no symptoms and yet go from vigorous health to death within a few hours. Survival from this type of plague is very rare indeed.

There were recurrent epidemics of plague in England throughout the fourteenth through seventeenth centuries, with the last being the Great Plague of 1665 AD. These did not have the same impact on mortality as the initial outbreak, but they served to establish plague as endemic in Britain (with up to a few hundred deaths per year across the country) and to keep the population in check for about 250 years.

PAST ASSESSMENTS OF PLAGUE MORTALITY

It is thought that either 3 or 4 new cemeteries were opened immediately in London in AD 1348–1350 to accommodate the increased number of deaths from the Black Death, but only two are known for certain, those at East and West Smithfield. Hawkins (1990) estimated that the Royal Mint site at East Smithfield originally contained ca. 2,400 individuals. He assumed a similar density of burials at West Smithfield, which was four times as large, and calculated a figure of ca. 10,000 burials for that cemetery. This gives a total of ca. 12,400 for both cemeteries, which, he argued, could represent “the great majority of Londoners killed by the Black Death.” If the lower figure by Smith (1991) of 40,000 is taken as the correct estimate for the population of London at about this time, then this figure constitutes almost one third of the population. If, however, the estimate by Keene (1984) of 100,000 is used, then the 12,400 of Hawkins (1990) is about one eighth. Hawkins (1990) argued that the numbers buried in the city’s churches and churchyards, about 100 sites in total (Hawkins, 1990), are impossible to calculate accurately, but many were probably filled very quickly.

Pollitzer (1954, pp. 503, 517) noted that there is no evidence to indicate that any particular age or sex group was affected more than another by any of the three forms of plague. Ziegler (1969, p. 137), too, mentioned its indiscriminate nature. Observable differences in mortality rates between age and sex groups are often considered to be owing to the likelihood of exposure to the risk of infection, although Chanteau et al. (2000) suggest that males have a greater inherent susceptibility, in their study of modern plague in Madagascar. The later outbreaks, such as the one in 1361 AD, which was known as the “children’s plague” (Sloan, 1981), are known to have affected young children more frequently than other age groups because the rest of the population would have acquired a certain amount of immunity through previous exposure to the disease.

MATERIALS AND METHODS

This research involves the study of human skeletal remains from two medieval cemeteries: the Royal
Mint site in London and St. Helen-on-the-Walls in York. The Royal Mint was built on the site of a Black Death cemetery (Honeybourne, 1952; Grainger and Hawkins, 1988; Mills, 1985). This cemetery was in use for only a few months in 1349 AD as a repository for those who died from plague, and thus the cemetery can be categorized as “catastrophic.” The individuals buried during this short time span should, theoretically, be more representative of the original “living” population than those from a long time-span cemetery, although in practice there are many factors that could adversely affect the level of representativeness (Margerison, 1997; Waldron 2001). In contrast, the cemetery of St. Helen-on-the-Walls in York was in use for about 400 years. It is termed an “attritional” cemetery because it represents the gradual attrition (accumulated deaths) of a population over a long period of time.

In both samples, there were a number of individuals who could not be assigned to age and sex categories and so have been omitted from the mortality profiles. We recognize that sampling effects may have had an influence on the profiles, but these are not considered to have affected overall trends. Margerison (1997) discussed causes of potential bias in the samples at length. It would have been possible to allocate the unknowns to categories based on assumptions of even distribution (Waldron, 2001), but this technique may mask important aspects of the data and adds another potential bias to the analysis.

The Royal Mint site, London

The Black Death cemetery, here referred to as the Royal Mint site, was positioned just outside the city walls near East Smithfield in the parish of St. Botolph, Aldgate, to the northeast of the Tower of London. Only a small part of the area had actually been used for burials, and these occurred in two distinct areas (Fig. 1). The western area consisted of two mass burial trenches and 11 grave rows, and the eastern area contained one burial trench and three grave rows. Remains from 900 individuals had to be reburied owing to contamination by heavy metals from the Mint workings above, leaving 600 available for examination (Waldron, 2001), which is 25% of the estimate by Hawkins (1990) of 2,400. The stratigraphic relationship between the graves and the trenches could not be established during excavation, but one of the trenches and several of the graves were open for some time before use (Hawkins, 1990). The trenches were filled from south to north, with densely laid burials up to five deep in places. They were organized methodically, however, and the bodies were laid with care and covered with a layer of earth.

A mix of both sexes and all ages are represented, and there was no noticeable segregation of individuals by age or sex (Waldron, 2001). Evidence from contemporary documents (Bowsky, 1971) suggests that the death toll was so high that it was necessary to dispose of the bodies in the quickest and most convenient manner. Anyone who died within the geographical catchment area of the cemetery would probably have been buried there, regardless of their social standing. The preservation conditions and general condition of the bones from the site are fairly good, but owing to fragmentation of the skeletal material and absence of relevant skeletal elements, problems with aging and sexing were experienced.

St. Helen-on-the-Walls, York

The church and cemetery of St. Helen-on-the-Walls were on the site later occupied by the Ebor Brewery. A sequence of five rebuilds and expansions of the church was uncovered, dating from the tenth century to the late fifteenth century (Dawes and Magilton, 1980, pp. 6–7). The church went out of use in 1550 AD, at a time when many other poor parish churches were suffering a similar fate. While not specifically designated as a plague cemetery in 1349–1350, it would undoubtedly have contained some of the victims. Fluctuations in burial rates of this kind in a long time-span cemetery even themselves out over the years (Buikstra and Mielke, 1985), although recent papers by Keckler (1997) and Paine (2000), using paleodemographic modeling, suggest that periodic episodes of catastrophic mortality may have lasting effects on age-at-death distributions.

Fig. 1. Plan of Black Death burials within Royal Mint cemetery (after Grainger and Hawkins, 1988).
The majority of the inhumations date from the third rebuild in the early fourteenth century onwards, producing a minimum of 1,044 individuals. Dawes and Magilton (1980, p. 9) estimated that about two thirds of the original area of the St. Helen-on-the-Walls cemetery was excavated and, because the burials were evenly distributed, they concluded that they had probably recovered about two thirds of the original number. The burials were densely packed with little respect for previous burials, a situation that resulted in overlapping, damage, and considerable fragmentation of some skeletal remains. The preservation conditions and general condition of the bones from St. Helen-on-the-Walls are good but, owing to fragmentation of skeletal material and absence of relevant skeletal elements, problems with aging and sexing were experienced. The cemetery contained representatives of all age categories and sex groups, suggesting that “blatant burial selection criteria were not practiced” (Grauer, 1989, p. 43). Grauer (1989) did find, however, a low proportion of subadults to adults, which she proposed was due to the exclusion of many unbaptized infants aged 0–1 years.

**Techniques of age estimation and inter- and intraobserver error assessment**

It was not possible to reassess completely the skeletal material from the Royal Mint site; therefore, the data of Waldron (2001) were used. Inter- and intraobserver error checks were conducted, however, using the same age-estimation techniques as were used for the reassessment of the St. Helen-on-the-Walls material, and a satisfactory level of agreement was reached. The subadult skeletal material was assessed for age, using dental development (Ubelaker, 1989), and ossification and epiphyseal fusion (Williams and Warwick, 1980), supported by long bone length (Sundick, 1978). The main techniques used on the adult material were epiphyseal fusion (Williams and Warwick, 1980), dental eruption (Ubelaker, 1989), and dental attrition (Brothwell, 1981), as well as age-related pubic symphysis (Brooks and Suchey, 1990), iliac auricular surface (Lovejoy et al., 1985), and sternal rib-end morphology (Iscan et al., 1984). The reasons for these choices and a detailed explanation of the inter- and intraobserver error checks are given in Margerison (1997).

**Comparisons**

**Comparison one.** Are the mortality data from a catastrophic event different from the mortality data from natural attrition? If so, then how this manifests itself would depend on the particular disease in question. Can this disease be identified? If the epidemic were of an indiscriminate nature with regard to age and sex, then would one expect the population represented by the Royal Mint sample to be dying on average relatively younger than its St. Helen-on-the-Walls counterpart?

**Comparison two.** Are the mortality data from a medieval plague cemetery different from the expected attritional medieval mortality? Data from the Royal Mint site were compared with a model population (Weiss, 1973). The advantages and limitations of using such populations are discussed elsewhere (Buikstra and Mielke, 1985; Howell, 1986; Jackes, 1992). The method used for deciding which model table to choose for this study is described below. It is expected that there will be demonstrable differences between the Royal Mint profile and that of the model population, thus supporting the findings of its comparison with the St. Helen-on-the-Walls profile.

**Statistical analyses**

Each profile is described, and differences between them are highlighted. The Kolmogorov-Smirnov statistical test (Siegel and Castellan, 1988) was used to verify the significance of these differences. This is a nonparametric test of whether or not two independent samples have been drawn from the same population, and is based on the difference between two cumulative distributions. The tests upon which the model life-tables rely use the figure for $T(0–4.99)$ from the life table as an estimation of the population size (“n”) for the Kolmogorov-Smirnov test, because no other figure is given for this in the model life-table series of Weiss (1973).

**Choosing a model table**

A model population was chosen from the tables of Weiss (1973) that was considered to best represent the suspected mortality conditions pertaining in the medieval period. These tables of Weiss (1973) were preferred because they are, at least partially, based on archeological samples. Ascádi and Nemeskéri (1970, p. 250) estimated a model life-table for tenth to twelfth century Hungary. While their life-table may not be directly comparable with one from fourteenth century England and their method of estimating the table may be open to criticism, as only the mean age at death and survivorship at age 15 are required, it was deemed acceptable to use these data to determine which of the model life-tables of Weiss (1973) to use for comparison with the Royal Mint data. The mortality profile from the Royal Mint is, therefore, compared with the model life-table MT: 30.0–60.0 of Weiss (1973), because the life expectancy in medieval Hungary at age 15 was 30 years and the survivorship was 60 years.

**RESULTS**

**Description of mortality profile of the Royal Mint site, London**

Out of a total number of 600 skeletons from the Royal Mint site, 178 can be classified as subadults (under 15 years old) and 295 as adults (over 15 years old) and assigned to one of the 10-year categories (Table 1). This totals 473, but there are 48 males and...
50 females who cannot be assigned an age, and 27 adult individuals who can be assigned neither sex nor age. These, and the two individuals who can be placed in neither the subadult nor adult category, have been omitted from the mortality profiles (Fig. 2). The subadult to adult ratio is 42:100. The male to female ratio is 127:100. These ratios include those who could be assigned a sex but no age, and an age but no sex.

The profile in Figure 2 shows the mortality distribution for the Royal Mint site, while the profile in Figure 3b shows the expected distribution for catastrophic mortality. There are two major differences between the two profiles: there are relatively few individuals assigned to either the infant or the 15–24.99-year age categories at the Royal Mint site, and there is a higher number of juveniles than might be expected. The last two categories, the middle-aged adult and the old adult group, are equal in number, but this is due to the last category being open-ended and thus includes individuals of 60, 70, 80, and older. If this age category were divided into 10-year groups like the other categories, then a reduction in numbers in the higher age categories would be seen. This would be more consistent with the expected catastrophic distribution.

### In summary

In summary, the profile of the Royal Mint data coincides generally with what one would expect from a catastrophic population, but two main points for discussion have emerged: 1) the pattern of subadult mortality, i.e., there are few infants and many juveniles; and 2) there are very few young adults.

#### Description of mortality profile of St. Helen-on-the-Walls, York

Out of a total number of 1,044 skeletons examined from St. Helen-on-the-Walls, 300 can be assigned to either the infant or juvenile categories, and four others can only be identified as subadult, while 336 can be classified as adults and assigned to one of the 10-year categories (Table 1). This totals 636, but there are 146 males and 157 females who cannot be assigned an age, and 97 adult individuals who can be assigned neither sex nor age. These, and the four individuals who can be placed in neither the subadult nor adult category, have been omitted from the mortality profile (Fig. 2). The subadult to adult ratio is 41:100. The male to female ratio is 89:100. These ratios include those who could be assigned a sex but no age, and an age but no sex.

The profile in Figure 2 shows the mortality distribution of St. Helen-on-the-Walls, and that in Figure 3a shows the expected distribution from attritional mortality.
mortality. Fewer than half of the subadults were infants, and it is suggested that the site may be suffering from infant under-enumeration. There is a high number of juveniles, which is contrary to the expectation from an attritional cemetery, but the 15–24.99-year-old category contains very few individuals, which is to be expected because this group should be the most fit and healthy and should not be dying. Similarly, there are few people in the 25–34.99-year range, while the peak is in the middle-aged range, i.e., the 35–44.99-year-olds. There are slightly lower numbers of people in the over 45-year-old category than in the preceding one, which reflects the fact that it is unlikely, although not impossible, that many people would live to a very old age.

In summary, the St. Helen-on-the-Walls profile corresponds well to the expected attritional mortality profile for a poor, medieval, urban parish. There is only one major discrepancy: the high number of juveniles.

Results of statistical tests

Comparison one: the Royal Mint and St. Helen-on-the-Walls. H0 means that the mortality of a catastrophic cemetery is the same as that of an attritional cemetery. H1 means that the mortality of a catastrophic cemetery is different from that of an attritional cemetery.

Using the Kolmogorov-Smirnoff test, the maximum difference between the two samples (0.095) exceeds Dm,n (0.083), and therefore H0 is rejected. The age category which contributed the most difference is the 5–14.99-year category.

Comparison two: the Royal Mint and a model population. H0 means that the mortality of a medieval plague cemetery is the same as the expected medieval mortality. H1 means that the mortality of a medieval plague cemetery is different from the expected medieval mortality.

Using the Kolmogorov-Smirnoff test, the maximum difference between the two samples (0.111) exceeds Dm,n (0.068), and therefore H0 is rejected. The values are also significant at the significance level of P < 0.001 (Dm,n = 0.097). The age category which contributed the most difference is the 15–24.99-year category.

It must be noted that in a Kolmogorov-Smirnoff test comparing St. Helen-on-the-Walls with the model population, the null hypothesis (that they were the same) was also rejected. This does not detract from the results, as it was already stated that St. Helen-on-the-Walls differs from the expected attritional mortality because of the large number of juveniles in the sample. This will be discussed below.

DISCUSSION

The Royal Mint sample corresponds generally with the expected catastrophic mortality pattern, with two discrepancies: 1) the pattern of subadult mortality; and 2) the lack of young adults in the 15–24.99-year age range. To take the first point, there are lower numbers of infants and more juveniles than might be expected from either a cemetery population of the medieval period or a catastrophic mortality distribution. This may be owing, in part, to infant underrepresentation resulting from taphonomic or social factors (Bocquet-Appel and Masset, 1982; Guy et al., 1997; Grauer, 1989). An alternative interpretation, however, can be suggested. High fertility, coupled with high infant mortality in the medieval period, may have reduced the numbers of infants alive in the population at any time. Even if infants who perished from other causes during the period of use of the Black Death cemetery were included in the sample, this would not add many to the expected total because of the short time span involved.

The high proportion of juveniles indicates that there must have been a large number of this age category in the population that contributed to the Black Death cemetery. If there were few infants, then where did the juveniles come from? It is known that migration into cities at that time was quite high (Keene, 1989), but this necessitates that it was people with young children who were migrating. While this is not impossible, it is probably not the complete story. This group was perhaps more likely to be exposed to infection or could have been coincidentally affected by other diseases/environmental factors, which were more dangerous to this age group. Bing and McNeal (1997) refer to the years from 5–7 and 9–12 as an extended middle childhood, a period when children develop many new capacities. They report that 5–7-year-olds participate significantly in tasks related to family and group survival, and suggest that these contributions provide an inclusive fitness benefit that may have contributed to the evolution of the 5–7-year transitional period. In the context of the St. Helen-on-the-Walls site population, this could have exposed children to the health risks of adults without the benefit of a fully developed adult autoimmune system.

The second discrepancy is the lack of individuals in the 15–24.99-year age group. In a medieval population, one would expect there to be many individuals in this age group, comprised perhaps of migrant workers coming to the city to take up employment and an independence and mobility, however, could offer the explanation of why there are so few of this age group represented at the Royal Mint site. They were, perhaps, more willing and able to leave the city at the first sign of the disease. In support of this assessment, Boccaccio (1972, p. 53) stated, “Some people, pursuing what was possibly the safer alternative, callously maintained that there was no better or more efficacious remedy against the plague
than to run away from it. Swayed by this argument, and sparing no thought for anyone but themselves, large numbers of men and women abandoned their city, their homes, their relatives, their estates, and their belongings and headed for the countryside either in Florentine territory or, better still, abroad. It was as though they imagined that the wrath of God would not unleash this plague against men for their iniquities irrespective of where they happened to be, but would only be aroused against those who found themselves within the city walls...” Similarly, in the *Journal of the Plague Year* (Defoe, 1960, p. 18), the narrator’s brother, referring to the outbreak of plague in London in 1665 AD, says that he has heard “that the best preparation for the plague was to run away from it.”

The number of individuals in the 25–34.99-year range is consistent with the expected distribution for catastrophic mortality because it is likely that there would have been a large number of individuals alive in this age range, perhaps as a result of migration. The mortality profile for St. Helen-on-the-Walls corresponds reasonably well with the expected distribution for an attritional cemetery. Grauer (1989, pp.108–113) suggested that the reason for the low number of infants is not the preservation conditions, but the exclusion of unbaptized infants from the cemetery, in addition to an excess of adults due to immigration. The very large number of juveniles, however, is unusual because this age group should not be dying in such numbers. Brothwell (1987) noted that the risk of dying in the first 0–4 years of life, and especially in the first year, is greatest from infectious and other parasitic diseases. If an individual survives to age 5 years, then the risk of dying in the next few years, up to adulthood, is lower. Certain infections and deficiencies could have maintained a high mortality rate in this age group, perhaps due to the cause suggested by Bing and McNeal (1997), that children could have been exposed to many of the risks faced by adults. Grauer (1989, p. 167–172) found that the population of St. Helen-on-the-Walls was subject to nutritionally based stressors and infection. Subadults were more likely to display few lesions associated with either of these stressors, and Grauer (1989) concluded that they died before their skeletons could be affected. The frailty of juveniles of St. Helen-on-the-Walls was most likely the result of poor diet and the squalid conditions that were documented for medieval urban environments (Sabine, 1933, 1934, 1937; Knüsel, 1989; Dyer, 1989). Another possible explanation is that people from other parishes of York were preferentially interring their children in the cemetery of St. Helen-on-the-Walls, because the fees may have been lower than elsewhere. This pattern of high juvenile mortality is, interestingly, also reflected in the data from the Royal Mint and the model populations of Weiss (1973; MT:30.0–60.0 and MT:35.0–40.0). It is unlikely that any of these populations could have maintained themselves without immigration (cf. Dyer, 1989).

The aim of this study was to attempt to identify the passage of an epidemic disease through a population. The expectation is that the skeletal sample from the Royal Mint site, a known Black Death cemetery, will have a different mortality profile from cemetery derived from natural wastage, such as St. Helen-on-the-Walls. This is confirmed by comparison one, which shows that the difference between the two sites is significant at $P = 0.05$.

The peaks in mortality at the two sites are in the 25–34.99-year age group at the Royal Mint site and in the 35–44.99-year age group at St. Helen-on-the-Walls. In an attritional cemetery, this is where one might expect the peak to be, unless sex-specific mortality figures indicate that females were dying younger because of deaths in childbirth. The unadjusted figures by Waldron (2001) for the later, attritional graves from the Royal Mint site also show a slight peak in the 35–44.99-year-old category. If, therefore, a mortality profile has a peak at a younger age in both sexes, then one should look closely at the possible reasons for this, including the possibility that the population had experienced an epidemic. In practice, burial context is likely to give an indication of the circumstances under which death and burial occurred, but this cannot be relied upon in every instance as, for example, not all of the Royal Mint burials were in common pits; some were buried in individual graves during the same period.

Finally, there could be other explanations for a younger average age-at-death than an epidemic disease, e.g., war, famine, and massacre. War victims are likely to be young adult males, are likely to display a high prevalence of trauma, and therefore are likely to be easily detectable through osteological examination (Stroud and Kemp, 1993; Boylston et al., 1997; Fiorato et al., 2000). Famine is likely to affect the most vulnerable members of the population first (the very young and the very old), and so would mimic natural attrition or a disease which affects these ages. This pattern was found in the study of deaths among the Donner party, where the youngest and oldest members of the group were found to be the most likely to die from starvation and exposure to cold (Grayson, 1993). Massacre could affect all ages and both sexes, unless the attackers had a particular reason for removing certain groups and, again, there is likely to be a high rate of trauma, as at the Crow Creek site in South Dakota (Willey and Emerson, 1993). The demography of such a site, assuming that all age groups were treated in the same manner, would have the same profile as an indiscriminate epidemic disease. If a particular sex was not represented or poorly represented at a certain age, then this would be detectable in the skeletal analysis.

The aim of identifying the passage of a disease through a population in the absence of archeological context or historical records has been met with some provisos. This research shows that there are features
of the mortality profile of an epidemic, whether indiscriminate or not, which distinguish it from an ordinary mortality profile. Some of these may have been modified by the behavior of the population. The number of 15–24.99-year-olds is depleted in the Royal Mint data. One explanation of this is that this age group was the most independent and mobile and, therefore, the one most able to escape from the effects of a mass contagion. This factor gives the Royal Mint site a characteristic more usually associated with an attritional profile, though there is still a significant difference between the attritional and Royal Mint site profiles. Similarly, the hypothesis suggested above, that the low proportion of infants could be a demographic reality in an indiscriminate epidemic, also mimics an attritional profile that suffers from infant underenumeration. Massacre is another possible explanation, but if this were the case, then there should be evidence for trauma on the skeletal remains. A disease such as cholera, which discriminates or not, which distinguish it from an ordinary epidemic, whether indiscriminate or not, which distinguish it from an ordinary epidemic, also mimics an attritional profile that suffers from infant underenumeration. The most striking feature of the indiscriminate epidemic profile, therefore, is the peak in mortality of the 25–34.99-year-olds. This is irrespective of sex, so it cannot be associated with childbirth (Margerison and Knüsel, 2001). These young adults should not be dying, so the possibility of the population being affected by an indiscriminate epidemic could be considered for a profile that has a peak in this age group. Massacre is another possible explanation, but if this were the case, then there should be evidence of trauma on the skeletal remains. A disease such as cholera, which discriminates by affecting the very young and the very old, is unlikely to be identified from the paleodemography alone, because the paleodemographic profile resembles an attritional one (Margerison, 1997).

**CONCLUSIONS**

It was expected that it would be possible to demonstrate from the demographic characteristics of a population alone that that population had been affected by factors other than natural wastage. This study has shown that this is indeed the case, although it is not likely to be possible to say whether or not these factors were the result of a specific epidemic without the archaeological evidence of a mass burial.

It was expected that an archeological population that had suffered the onset of an epidemic disease would experience differences in mortality from one that had not. The results of this research suggest that an indiscriminate catastrophic event in a preindustrial population shows characteristics of the expected profile of the living population but, as was discussed by Waldron (2001), there are many factors, mainly unknown, that prevent the demographic evidence from plague pits from being representative of the population from which it was derived. It is suggested by the results of this research that an indiscriminate catastrophic event in preindustrial populations can be defined by three main factors taken together:

1. A relatively low proportion of infants;
2. A low proportion of 15–24.99-year-olds; and
3. A peak in the young adult age group.

Figure 4 compares the effect of this with the conventional profile for catastrophic mortality previously presented in Figure 3. If the population has a low proportion of infants, and there is no obvious reason to believe that this is because of infant underenumeration, then the possibility that this is a demographic reality should be considered. A high proportion of infants in a catastrophic sample, on the other hand, may indicate that the catastrophe was a disease that affected infants more than others. In an unknown sample, a lack of individuals in the 15–24.99-year age range might be expected. In an indiscriminate catastrophic sample, there should be a high proportion of this age group. In practice, this study argues that, being the most independent and mobile members of society, these individuals are likely able to flee from the perceived disease focus (Boccaccio, 1972; Defoe, 1960). It is also possible that the pattern of adult mortality (a peak in the 25–34.99-year age group) of such a disease could be mistaken for another catastrophe, i.e., massacre. If this were the case, then there should be evidence for trauma and, in practice, it is unlikely that a massacre would be confused with an epidemic. There is some evidence for trauma at the Royal Mint and St. Helen-on-the-Walls sites, but not of the kind or of sufficient quantity for the sites to be mistaken as massacre sites if the context were unknown (Davies and Magilton, 1980; Waldron, 2001).

The effect of a peak in the young adult mortality on the population is not only from the loss of those people; it also means the loss of the children that they would have had. This, in combination with the
successive loss of more children in later outbreaks of plague, would have contributed to curbing of the growth of the population for the next 200 years.

Finally, most archeological skeletal samples are likely to be biased, so although there are undoubtedly differences between catastrophic and attritional cemeteries, they are unlikely to be sufficient for an epidemic, whether indiscriminate or not, to be unconditionally diagnosed in the absence of archeological context and historical records. A disease which discriminates against the very young and old mimics the attritional profile and, therefore, is unlikely to be identified. It is certainly not possible to identify the particular pathogen which might have caused the epidemic from paleodemography alone. This study, therefore, demonstrates the importance of using all the evidence from the archeological context and historical and documentary records, if available, to allow the best possible chance of understanding the site and its human population.

ACKNOWLEDGMENTS

We thank Dr. Tony Waldron for allowing the use of his unpublished report and data, James Rackham for access to the Royal Mint material, and Elizabeth Hartley for access to the St. Helen-on-the-Walls material. We also thank, for their various contributions to B.J.M.’s Ph.D. dissertation, Dr. Brett Scaife and Dr. Dave Lucy for their statistical advice, Dr. David Gale for his editorial comments, and Dr. Charlotte Roberts, Dr. Terry O’Connor, Prof. Don Brothwell, three anonymous reviewers, and Dr. Emöke Szathmáry, Editor of AJPA, for valuable comments on the content and form of this contribution. The Science and Engineering Research Council, UK, funded the dissertation from which this contribution comes. None of these people or organizations is responsible for the final form of this contribution.

LITERATURE CITED


Paine RR. 2000. If a population crashes in prehistory, and there is no paleodemographer there to hear it, does it make a sound? Am J Phys Anthropol 112:181–190.

