The Black Death, Plague, and Mass Mortality

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Abstract: *Cultural funerary practices typically entail a set of common rituals, ceremonies, and treatments that are common to the cultural group. These practices are adhered to unless there is a significant culture change or the community experiences a catastrophe such as war, natural disaster, or epidemic. When such periods of disaster spread over a large territory and are experienced for a long period of time, such as during the epidemic of Black Death in Europe during the Middle Ages, it could be argued that the mass burials become a funerary practice in itself. There is value in identifying these catastrophic samples. By identifying the pattern of these mass burials researchers can identify such catastrophic examples with greater ease and place this distinct funerary situation within the larger context of funerary practices. The goal of this research is to distinguish the burial practices employed in Europe during the epidemic of Black Death from standard funerary practices at that time period and define the shift in burial practice as a funerary practice in itself. The pattern of mass burial observed during the Black Death epidemic will then be compared to other instances of mass burial to determine whether different causes for mass death and burial can be distinguished in the funerary practice.*

Introduction

The Black Death was one of the most devastating recorded catastrophes in human history. The widespread epidemic is estimated to have killed one-third to half of Europe's population (Grainger *et al*, 2008:1; Noymer, 2007: 616). The number of deaths is rivalled only by the 1918-1919 influenza epidemic, but in the 20th century, the human population had much greater numbers than during the Middle Ages (Noymer, 2007: 617). What happened during the Black Death is of great concern to researchers in a multitude of fields; not only for its historical and archaeological implications, but also to better understand current epidemiological concerns. This paper will first discuss the history of the Black Death; the context in which it occurred, its aetiology, and its effects. A description and discussion of funerary practices will follow; contrasting the normal pre-plague funerary practices with those adopted to dispose of overwhelming numbers of bodies. The Black Death mass burials will be compared to other instances of mass burial through history. Finally, this paper will discuss what knowledge derived from the archaeology of the Black Death and its implications for funerary archaeology, bioarchaeology, epidemiology, and forensic archaeology.

The History of Black Death in Europe

The social situation in Europe during the Middle Ages

The Middle Ages or medieval period refers to a long stretch in history between the 5th and 15th centuries (Noymer, 2007:616). This was a period when Christianity flourished and played a significant role in people's lives; influencing codes for proper behaviour (Ariès, 1976: 5). European cities experienced increased urbanisation and a great increase in their population (Antoine, 2008: 106). The Black Death occurred during the Late Middle Ages, a period when Europe was faced with many challenges. Northern Europe was greatly affected by famine, particularly the Great Famine of 1315-1317 caused by widespread crop failures as a result of abnormal weather (Antoine, 2008: 105). The Black Death entered Europe in 1346, quickly spreading throughout the continent and decimating its population.

The Black Death

The occurrence and devastation of the Black Death is undisputed. Several historical accounts describe its infectious nature and the widespread mortality in Asia, Europe, and Northern Africa between 1346 and 1351 and the subsequent reoccurrences of plague that persisted until the 17th century (Grainger *et al.*, 2008: 1, 10).

The Black Death is known for its incredible ability to kill. Old, young, male, and female; no one could escape the plague. However, it appears that its killing powers were not as indiscriminate as had been believed. DeWitte and Wood (2008) found that there remained some selectivity in the Black Deaths' victims. At East Smithfield, there is evidence that those who were most susceptible succumbed earlier to the plague. The individuals contained in mass graves are believed to be the first interred in the cemetery. There is a fairly equal representation of both sexes. Adults make up 59.5% of the assemblage, while the remaining 40.5% consists of juveniles, mostly older children (Grainger *et al.*, 2008: 49). Few of these juveniles are infants, although the underrepresentation of infants in the archaeological record is not uncommon due to differential preservation of more fragile skeletal element. In the individual graves at the same site, those believed to be occupied by later victims of Black Death, only 29% of individuals are juveniles. The majority consists of young and middle aged adults, between the ages of 25 and 45 (Grainger *et al*., 2008: 43). Members of the population who were less vulnerable to agents of death were still succumbing to the Black Death, although later than those with greater frailty. Therefore there may be an underrepresentation of the young and the old in burials dug towards the end of the epidemic.

Debate continues over what the Black Death actually was. 'Plague' is a general term used to describe a multitude of agents for widespread epidemics. The term 'plague' is also associated with the specific pathogen of *Yersinia pestis* (previously known as *Pasteurella pestis*) (Noymer, 2007: 617). *Y. pestis* was identified in 1894 as the agent causing an epidemic in Hong Kong (Cohn, 2002: 710). *Y. pestis* is spread by the rat flea and can be observed in three forms; bubonic, pneumonic and septicaemic (Noymer, 2007: 619). The fleas infect rats and

continue to accumulate bacterial reserves as they feed off of the rats. Once a plague-infected rat dies, the fleas find another food source, such as human beings, and by biting, proceeds to infect them (Noymer, 2007: 618). Farm animals have also been found to have been affected by the plague, with the exception of horses for which fleas have an aversion (Noymer, 2007: 619). The bubonic plague is most frequently associated with the Black Death. This form of plague manifests itself in the form of a high fever, delirium, severe aches, and a swelling of the lymph nodes, which is called a bubo (Antoine, 2008: 102). These buboes can develop within three to five days and will either burst or cause subcutaneous bleeding, the former of which may have caused the blue-black blotches reported for Black Death victims (Antoine, 2008: 102). Cohn (2002: 712) argues that these lumps may have been caused by other illnesses such as typhus or typhoid. If left untreated, the bubonic plague kills 50% to 60% of those infected after only eight days (Noymer, 2007: 619). The pneumonic version of the plague occurs when the infection spreads to the lungs. This often causes pneumonia and becomes highly contagious (Noymer, 2007: 619). Septicaemac plague occurs when the bacteria enters the bloodstream. Even in modern cases, this is almost always fatal (Noymer, 2007: 619). With no previous exposure and potential to build immunity, the entire medieval population would have been susceptible to *Y. pestis*.

Some remain doubtful that it is indeed *Y. pestis* that is responsible. Certain areas of Europe, such as Iceland, reportedly did not have rats (Antoine, 2008: 103), but these areas were also affected by the Black Death later and less severely. It is also difficult to attest to the presence or absence of rodents in certain areas since they do not typically enter the archaeological record; they were not habitually consumed as food nor buried as form of ritual. Cohn (2002: 712) argues that the movement and transmission of plague was much too rapid to have been spread by rats. Accounts of symptoms and signs of the plague from the Middle Ages are variable and sometimes vague. Some of the symptoms that had been reported do vary from symptoms observed in plague victims today. Most buboes were reported to be on the neck while the bubonic plague manifests itself mostly in the groin or armpit (Cohn, 2002: 717). In a time of religious propriety, doctors might not necessarily have checked a patients' groin area, especially if they were female. The plague appears to have been much more contagious than it is today, although the modern resistance to plague may to due to acquired immunity. Cohn (2002) is convinced that the Black Death was not the bubonic plague and argues that the differences between Black Death and current manifestations of the bubonic plague are too great for them to have the same aetiology. However, Cohn does not take into consideration the potential for pathogens to change and evolve through time, as well as the impact of acquired immunity on transmissibility.

Paleopathological analysis is problematic in that bone has a limited range in reaction as a result of any pathological disorder and that a certain

amount of time is required before a pathological lesion can manifest themselves on the skeleton. Plague or Black Death does not appear to leave any visible lesions on skeletons. Even if it did, most victims were killed so quickly that very few would have evidence of these lesions. The presence of plague must therefore be detected biochemically.

Several attempts have been made to detect *Y. pestis* in known or suspected Black Death or other plague graves. The early successful detections were criticized for poor precautionary measures, faulty methodology, and possible contamination (Raoult *et al.*, 2000: 12,800). Raoult *et al.* (2000) attempted to address these concerns. They analyzed samples from three individuals from Saint-Côme and Saint-Damien, an 800 grave cemetery used between the 9th and 17th centuries in Southern France (Raoult *et al.*, 2000: 12,800). The individuals used come from a section of the cemetery dated between the 13th and 15th centuries using historical data, stratigraphy, ceramics analysis, and radiocarbon dating (Raoult *et al.*, 2000: 12,800). A total of 23 intact teeth were collected from the possible plague victims and four negative control samples were collected from another French site with no history of plague (Raoult *et al.*, 2000: 12,800). Samples were taken from the dental pulp of these teeth in laboratories that had never contained *Y. pestis*, and were amplified using a method called 'suicide PCR (polymerase chain reaction)' where the primers are destroyed after one use, preventing contamination (Raoult *et al.*, 2000:12,801). *Y. pestis* was detected in 20 of the 23 samples, therefore each individual tested positive for the pathogen (Raoult *et al.*, 2000: 12,801). The pathogen was not found in the negative controls. Tran *et al.* (2011) tested for plague as well as seven other potential pathogens including anthrax, typhus, typhoid, and smallpox, using 173 samples from a medieval Venetian cemetery from the 14th to 17th centuries containing mass burials. Trench fever (*Bacterialis quintana*) was detected in 2.9% of samples and *Y. pesti*s in 1.7% (Tran *et al.*, 2011: 2).

The obvious limitation to the use of biochemical testing such as PCR genetic analysis is that it is very expensive and time consuming, which would greatly limit the number of samples that can be taken and processed. In France, a quick and inexpensive test, the Rapid Detection Test (RDT), which detects antigens for *Y. pestis*, is available through the Pasteur Institute, which also first discovered the pathogen (Bianucci *et al.*, 2009: 616). Bianucci *et al.* (2009) applied the RDT to suspected plague victims in France from the sites of Sainte-Croix and La Chaize-le-Vicomte. Both bone and dental samples were used for four nuns and two priests from the sites. Samples were also taken of the soil in the graves, to detect possible soil contamination of the skeletal remains, as well as control samples from a site with no history of plague (Bianucci *et al.*, 2009: 616-619). The RDT provides a quick diagnostic result. If two bars appear on the strip of paper, it is positive for the antigen, if only one bar appears, it is negative (Bianucci *et al.*, 2009: 618). At least one sample for each of the suspected plague victims tested positive for the *Y. pestis* antigens. Two samples

taken from spongy bone gave negative results, but these results were explained by the higher capability of preservation of genetic information in teeth and the fact that these spongy bone samples yielded levels below the minimum threshold for the test (Bianucci *et al.*, 2009: 619). All eight control samples and the soil samples tested negative for the antigens, confirming that there was no contamination (Bianucci *et al.*, 2009: 619). Kacki *et al.* (2011) also successfully detected plague in a rural French cemetery using the RDT. Of the 14 samples taken from potential plague victims, four tested positive. Seven of the negative tests were doubtful since the samples used were below the tests' threshold (Kacki *et al.*, 2011: 583). The difficulty of obtained enough of a sample to meet the RDT's threshold appears to be the greatest restriction with this test, but it does provide a useful and more affordable alternative to PCR, especially to obtain preliminary results.

To date *Y. pestis* has been detected in several suspected plague sites using different methods. The question remains, how many positive samples for one site are enough to consider the cemetery or mass graves to be the result of plague? Also, how many positive results are needed to convince the sceptics that the Black Death and the bubonic plague are one and the same?

The after-effects of the plague

While the Black Death was at its peak, most government activities and major industries ground to a halt causing crime and disorder to flourish (Bowsky, 1964: 24). Once the epidemic had become less virulent, it took a great deal of time to return government and industry into semi-regular operation. The epidemic provoked new developments in legislation concerning sanitary practices in an attempt to prevent and control further outbreaks (Bowsky, 1964: 14).

After the Black Death decimated Europe's population, many villages were left in a precarious, unstable situation. In comparison to typical mortality patterns, the Black Death killed more young adults and children, demographic groups that normally have low mortality. This removed many individuals of reproductive age from the population and decreased the birth rate that was so desperately needed to replenish the population. It is estimated that Europe's population did not recover from the effects of the Black Death until approximately 1470, over 100 years after the beginning of the plague (Grainger *et al.*, 2008: 26). As a result of widespread death, there was a great shortage of labourers, leaving many construction projects delayed or unfinished and fields uncultivated and sterile (Bowsky, 1964: 24). The shortage of people to fill necessary offices opened many previously restricted political, religious, and military positions to a wider pool of possible candidates (Bowsky, 1964: 20).

The Black Death led to further developments in medicine. Doctors had attempted to use the knowledge that they had about illness to treat those afflicted with plague, but had very little success. With time, doctors began to understand the concept of immunity and how such immunity can be built (Cohn, 2002:

710). This may have been the intention behind the practice of teeth taken from plague victims being used as amulets and swallowed to prevent illness by the Black Death (Raoult *et al.*, 2000: 12,802).

Towards the end of the Middle Ages, perceptions of death changed. It was no longer a peaceful event, but something to be feared. The imagery associated with death and funerals changed from peaceful expressions to ugly, infected corpses (Ariès, 1976: 52). This new fear of death encouraged a renewed religious devotion now with the intention of ensuring ones' personal safety through the hands of God (Bowsky, 1964:15-16). This became a prosperous time for the church and religious institutions. Not only were the people becoming more devoted, religious institutions became very wealthy in the aftermath of the Black Death. Many individuals on their deathbeds with no remaining family bequeathed their possessions to the church (Bowsky, 1964: 16).

Funerary Practices and Disposal of Bodies

Normal funerary practices during the Middle Ages

During the Middle Ages, Christianity played an important role in people's lives. A proper burial could be expected for all good Christians. Often a person knew that their death was eminent. They had confidence that they were safe in the hands of God and would be at peace in the afterlife (Ariès, 1976: 2). The funerary ritual was often organized by the dying person themselves prior to their own death (Ariès, 1976: 11). The funeral itself should be very simple and reserved. Great shows of emotions were frowned upon (Ariès, 1976: 12). Bodies were typically laid out in individual graves, although multiple graves did occasionally occur, usually multiple members of one family that died close in time to each other (Kacki *et al.*, 2011: 581). Bodies were stripped naked, washed, wrapped in a shroud and either placed inside a wooden coffin or directly into the ground during burial (Kacki *et al.*, 2011: 582).

Burial practices during the epidemic

The Black Death was the cause of many deaths in 14th century Europe and drastically increased the mortality experienced in communities affected by the disease. Despite the universal spread and devastation of plague, reactions and funerary practices developed to handle such high body counts varied tremendously.

One of the most reliably documented Black Death assemblages comes from the East Smithfield cemetery in London, England. This cemetery was only in use between 1348 and 1349, during the height of the epidemic in London and might have been opened with the sole intent of accommodating the increasing number of plague victims (Grainger *et al.*, 2008: 1). The cemetery consists of a combination of both well-ordered rows of individual graves and long trenches for mass graves (Grainger *et al.*, 2008: 12). There was no way to distinguish the

temporality of graves; if they were all dug at the same time or separately (Grainger *et al.*, 2008:19). Since this cemetery was likely opened for the express purpose of burying plague victims, some graves might have been dug in advance, likely the mass graves first, in anticipation of the high mortality that would occur. As the death toll diminished, workers had the time to dig individual graves for the dead.

The mass graves at East Smithfield display a persistence of respectful and deliberate treatment of dead despite the large number of them and the epidemic circumstances. Corpses were carefully laid-out within the grave rather than tossed into it. To maximize the limited space, bodies were densely packed up to five deep (Grainger *et al.*, 2008:12). Infants and juveniles were used to fill any empty spaces between adult corpses. The vast majority of corpses were extended, although out of over 400 individuals in the mass graves, one was found flexed and another was prone (Grainger *et al.*, 2008). At least 51 of the individuals recovered from the mass graves are believed to have been buried in wooden coffins, although the evidence for this may be confounded with wooden planks which were sometimes used to carry the plague bodies to a burial location (Grainger *et al.*, 2008: 12-20). Few artefacts or grave good were recovered, although buckles, brooches, cords and textiles were found. These may have been part of clothing or burial shrouds. A few coin cashes were also found in the mass graves. At the time it was customary to bury the dead naked (Grainger *et al.*, 2008: 21). If the buckles and brooches came from clothing rather than burial shrouds, this means that the effort and risk was not taken to strip the bodies naked as was typically done. The presence of coin cashes attest to this, demonstrating that either victims were either buried quickly after death, or there was no desire to search bodies for any valuables (Grainger *et al.*, 2008: 21). Sites in Italy and France (e.g. Kacki *et al.*, 2011; Tran *et al.*, 2011) contain both mass burial and individual graves and both contexts yielded biochemically confirmed plague victims. Some of the mass graves in Venice differ from the others in that they appear to be more disorderly in the placement of remains than other plague pits (Tran *et al.*, 2011: 2). The number of bodies in these pits is comparable to those at East Smithfield, but if this cemetery and its workers were not prepared for such a large number of bodies, they might have needed to work with more haste and less precise and deliberate placement of the dead (see Figure 1). Kacki *et al.* (2011: 585) suggests that in rural locations or cemeteries catering to a smaller population a more ordered and rational approach was taken to burial of plague victims as workers were less overwhelmed by the number of dead.

Figure 1: Three suspected Black Death mass graves in Venice, Italy. Note the varying degree of orderliness and care in burial. (Tran *et al.*, 2011:2)

The individual graves used for some plague victims are consistent with those regularly dug for the dead in Medieval Europe (Grainger *et al.*, 2008: 20). Without the context and documentation available for East Smithfield, or the genetic identification of *Y. pestis* in French and Italian sites, these would likely not be considered as potential plague burials (see Figure 2).

Figure 2: Individual graves occupied by confirmed plague victims (Bianucci *et al.*, 2009: 617)

Considering the extent of the mortality caused by the Black Death, it appears that only a fraction of relevant burials have been found. Each cemetery is complex and constructed in its own unique context. As more medieval cemeteries are excavated and more potential graves of Black Death victims are discovered we continue to gain more insight on the spread of plague, who it affected, and how the dead were treated.

General patterns of mass burial

Burial is one of the oldest methods for the disposal of human remains. In instances of mass death, mass burials are one of the easiest ways to manage a large number of decedents (Perera and Briggs, 2008: 1). Mass burials can be found in a variety of contexts through all time periods. It is a way to dispose of human remains when there are many bodies to contend with at one time. Mass graves are typically the result of some sort of catastrophe; famine, epidemic, war, genocide, sacrifice, or natural disaster. Despite the variety of contexts in which mass burials may be encountered, there have been few attempts to develop a typology or classificatory system to describe and classify mass graves. The attempts that have been made to do so are mostly limited to forensic and human rights contexts. Jessee and Skinner (2005) propose a typology based on archaeologically distinctive characteristics, focusing on the events that contribute to a sites' formation. Their categories and typologies describe the multiple sites that may be involved before bodies are placed in a final location. Many of the evidential findings necessary to elucidate the typology of a site requires that an investigation be conducted not long after the burial occurs, enabling preservation of soft tissue, blood, and other perishable matter (Jessee and Skinner, 2005: 57-58).

Unfortunately, the descriptions and contexts are almost exclusively concerning execution or genocide. By focusing on the mass graves resulting from human rights violations and other violent situations, the other contexts in which mass burial may occur are ignored and the adequate research needed to better understand these contexts is not conducted. Perera and Briggs (2008) discuss the concerns that are raised about mass burials to accommodate the dead from natural disasters, using the 2004 tsunami in Sri Lanka as an example. Some graves were dug in a hurry and bodies were disposed of haphazardly, sometimes using heavy machinery to deposit them in mass graves (Perera and Briggs, 2008: 2). Not only is this treatment of human bodies extremely disrespectful, it does not take sufficient precautionary measures to allow for preservation and later identification of the deceased (Perera and Briggs, 2008: 2). This method for the disposal of bodies is in sharp contrast to most plague pits in which remains were laid to rest in an orderly fashion.

The demographic composition of larger mass graves is often the best indicator of their cause. In the case an epidemic or natural disaster, people of all ages and of both sexes should be recovered. This is the hallmark of a

catastrophic mortality model. Although absence of an age group may not necessarily preclude the possibility of such an event. Catastrophic assemblages need not include all ages and all sexes. It should reflect the entire population from which the cemetery or burials are derived. For example, several mass graves have been found that are composed almost entirely of men. Signoli *et al.* (2004) describe a mass grave in Lithuania from the Napoleonic period. The corpses were carefully buried simultaneously. No children were found. Most individuals were between the ages of 15 and 35, and 97% of the 1,952 individual who could be sexed were males (Signoli *et al.*: 2004: 224). This information along with buttons from uniforms support the belief that these are French soldiers who died outside of battle, which is consistent with accounts of starvation, exhaustion and typhus outbreaks (Signoli *et al.*, 2004: 220).

What Can Be Learned from the Black Death?

Mortuary archaeology and forensic archaeology

Mass graves are encountered in both past and present. Typically the past contexts are the realm of archaeologists and those studying mortuary patterns, while the present is left in the hands of forensic science. By keeping these two contexts separate the related fields fail to learn from each other. There is a lack of consistency in how mass graves are studied and classified (Jessee and Skinner, 2005). By looking at mass graves throughout time, patterns and typologies that are being neglected may finally be recognized and kept in consideration in modern investigations.

Epidemiology

Epidemiologists currently hold a renewed interest in the Black Death; its spread, its aetiology, and its effects (Cohn, 2002: 703). In our current society that is characterized by globalization and rapid transportation, the spread of infectious pathogens can reach all parts of globe more efficiently than ever before. Although *Y. pestis* in its current form is treatable with antibiotics if it is diagnosed early enough, bacteria and pathogens are constantly evolving into more powerful and resistant 'superbugs'. Some of these drug-resistant superbugs such as methicillin-resistant *Staphylococcus aureus* (MRSA) are already wreaking havoc in hospitals. By studying how epidemics such as *Y. pestis* spread and have evolved over time, epidemiologists can attempt to predict how pathogens might evolve and behave in the future, therefore allowing them to put measures in place to prevent or control its spread.

Bioarchaeology/Paleodemography

Archaeology has changed tremendously since its infancy. In the early days archaeologists were mainly treasure hunters looking for lost relics of ancient civilizations. Now, archaeologists are more concerned with understanding these past populations; their beliefs and their way of life. The science is moving away from looking at objects or skeletons in isolation and is

instead looking at the population as a whole.

Paleodemography is the study of the structure and dynamics of past population. Such a study takes skeletal, historical, and archaeological evidence to reconstruct and better understand the how past populations lived and died. In paleodemography, there are two main model categories for skeletal populations; attritional and catastrophic (Gowland and Chamberlain, 2005: 146). An attritional population is one that can be observed from a standard cemetery, representing everyone who died in a given population. The attritional profile consists primarily of infants, young children, and older adults. One of the limitations in studying an attritional sample is that there is selectivity in death; a problem discussed as part of the Osteological Paradox (Wood *et* al., 1992). Not all individuals have an equal risk for death; therefore an archaeological population cannot be interpreted as representative of the living population from which it was derived. A catastrophic model is obtained from some sort of calamity that causes mass death; whether by warfare, natural disaster, epidemic, or other means. The catastrophic assemblage is interpreted as more representative of the living population as the selective mortality that creates an attritional assemblage is not present. Black Death cemeteries have been considered the prime example of such a catastrophic population (DeWitte and Wood, 2008: 1436; Gowland and Chamberlain, 2005). However the assumption that such an assemblage is representative of the living population is faulty. DeWitte and Wood (2005) compared signs of frailty between East Smithfield, a documented Black Death cemetery, and two attritional cemeteries in Denmark. Although the Black Death assemblage showed less signs of selective mortality than the attritional cemeteries, selective pressures remained. It is reasonable to consider that selectivity exists whenever some members of the population survive. At East Smithfield, there is a greater concentration of children in the Southern end of the cemetery. This end is considered the location of the earliest plague victims (Grainger *et al.*, 2008:20), therefore children were among the first to die from Black Death exhibiting a higher susceptibility to the disease.

In recent years, paleodemography has come under heavy scrutiny. Many of the models used assume that the population is stationary, meaning there no growth or decline, and very limited emigration and immigration. A great deal of bias affects the construction of a skeletal assemblage. There is selectivity in death which determines who dies. Cultural mortuary practices determine who is buried and where. The remains that are buried are then subject to taphonomic processes such as soil pH, bioturbation, animal activity, etc. Whatever skeletal remains are preserved must then be found by archaeologists and then saved for future study (Milner *et al.*, 2008). The skeletal remains that are recovered require analysis by osteologists to provide the necessary information for paleodemography, the most useful being age and sex, but the presence of pathological lesions also have

implications. Age estimation methods have their own limitations. Some of these limitations have to do with the dual usage of these methods; in forensic and archaeological contexts. For the forensic archaeologist, accuracy is the greatest focus, while the paleodemographer is more concerned with accurately representing the age distribution of the population in question. Many methods have been found to reproduce the age distributions of the reference collections on which they were developed. This age mimicry is interpreted as the cause of a phenomenon termed the 'middle-age spread'; a high number of middle-aged adults, something that is not observed in any contemporary populations. To remove the influence of age mimicry, statistical methods such as Bayesian statistics and maximum likelihood estimation are used (Gowland and Chamberlain, 2005; Müller *et al.*, 2002).

Paine (2000) suggests that the 'middle-age spread' that perplexes paleodemographers may not always be caused by age estimation methods and may actually reflect a population that has undergone a severe change. To assess the long-term population effects of the Black Death, Paine (2000) constructed a model population, based on normal 14th century London demographics. In the second year of the model, risk of mortality for all age groups is increased by 30%, reflecting a conservative estimate of the death rate caused by Black Death (Paine, 2000: 184). This model is then projected using normal mortality rates for a total span of 100 years. Immediately after the 30% increase in mortality, a significant decrease is observed in the population between the ages of 3 and 50 (Paine, 2000: 187). At the end of the projection, 98 years after the increased mortality representative of the plague, there is still a demographic difference from the original population 99 years earlier, although these differences are not statistically significant (see Figure 3). By the end of the model, the population numbers are only 75% of the original population (Paine, 2000: 188). Paine (2000) suggests that it may have taken 150 years for Europe's population to fully recover from the effects of the Black Death. After 98 years, the greatest proportion of the population consists of young and middle-aged adults; the 'middle-age spread'. Based on this model, such a pattern may be the result of any period of mass death such as an epidemic, war or natural disaster. This is a valid consideration to keep in mind during any demographic study of past populations, especially if there is documentation of such a period of mass death.

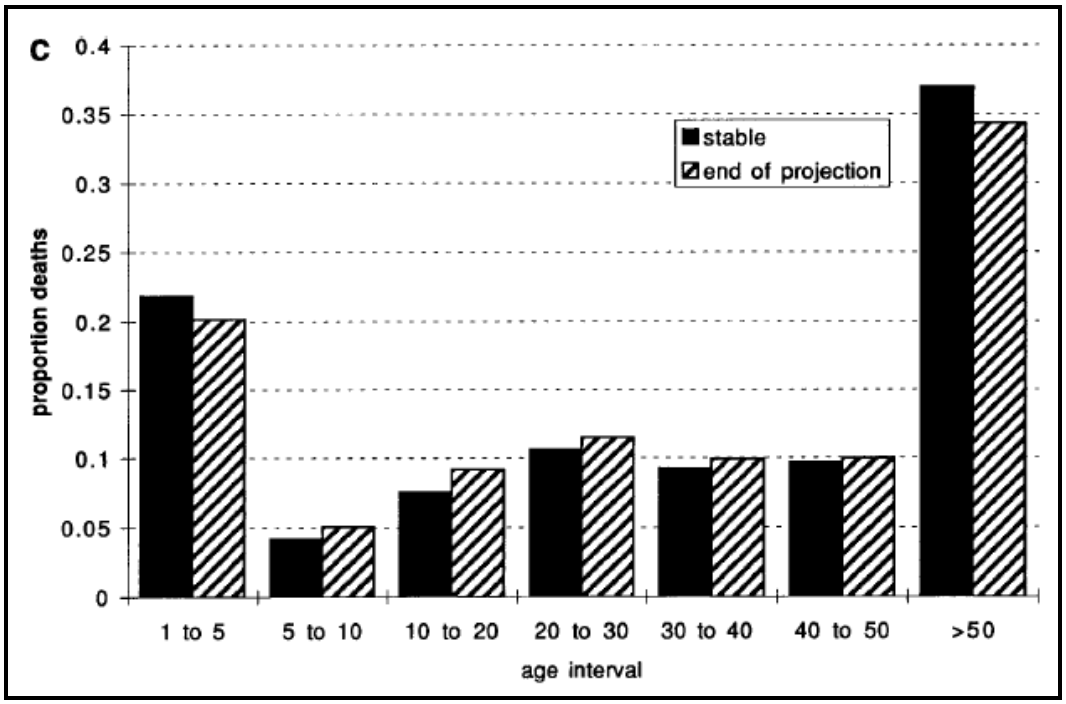

Figure 3: The comparative demographic levels between a stable population and a model population affected by the Black Death, 98 years after its occurrence (Paine, 2000: 187)

Antoine (2008: 113) suggests the possible influence of the Great Famine of 1315 to 1317 on survivorship during the Black Death. This is certainly an area that deserves further research. A period of nutritional stress would manifest itself on the bones of juveniles in the form of Harris growth arrest lines on long bones and dental enamel hypoplasia on teeth. Those who survived the famine would likely exhibit some form of skeletal stress. By observing the presence of these stress indicators in both plague victims and attritional deaths after the plague, bioarchaeologists could gain valuable information on the subject of survivorship, heterogeneous mortality, and the selective mortality of the Black Death.

Conclusion

The Black Death affected Europe during a period of highly regulated behaviour, dictated by rules and codes influenced by the Christian church. Despite the constraints on everyday life, the reaction and behaviours adopted to dispose of the overwhelming number of bodies ravaged by the plague vary tremendously. This is consistent with O'Shea´s (1984: 33-34) position that funerary practices are followed unless there is a significant cultural change or the community experiences a catastrophe. Although there is no

consistency in the way the living disposed of Black Death victims during the plague, this lack of consistency is in itself diagnostic. It demonstrates that the effects of the plague were significant enough to cause deviation from the strict pattern of burial previously adhered to and for an abandon of uniformity in this period of devastation. To better identify a potential Black Death mass grave, researchers can look at the demographic patterns. Since the Black Death killed with very little selectivity, a representative plague pit would contain victims of all ages and both sexes.

One of greatest concerns held by many researchers working with Black Death assemblages is demonstrating the actual aetiology of the Black Death; some are determined on proving the presence of *Y. pestis* in Black Death assemblages, while others continue to insist that some other agent was responsible for the plague. In this approach, thorough analysis of the actual burial patterns and context are being neglected. Some researchers (e.g. Kacki *et al.*, 2011) call for more attention to the mortuary archaeology rather than the biochemical analyses. It will be interesting to see in which direction research does progress now that the evidence in favour for *Y. pestis* has become much more convincing. The presence of *Y. pestis* could therefore serve as the ultimate diagnostic tool to identify plague victims.

Further study of the Black Death and plague cemeteries continue to contribute towards the advancement of many scientific fields. The patterns observed in mass burials can be used in current forensic analyses of human rights violations or other instances of mass death, and vice versa. Epidemiologists are greatly concerned about the ever-evolving pathogens that risk causing new epidemics. By studying past epidemics and the pathogens that caused them, epidemiologists can attempt to present or contain future outbreaks. The field of archaeology has greatly benefited from studies of the Black Death, not only through the historical knowledge gained, but also through further insight into paleodemographic challenges and concerns in paleopathology.

References Cited

Antoine, D. 2008. The Archaeology of Plague, pp. 101-114 in V. Nutton (ed.) *Pestilence Complexities: understanding Medieval plague.* Medical History, Supplement 27.

Aries, P. 1976. *Western Attitudes Toward Death From the Middle Ages to the Present*. Baltimore, Maryland: The Johns Hopkins University Press.

Bianucci, R., Rahdison, L., Peluso, A., Rabino Massa, E., Ferroglio, E., Signoli, M., Langlois, J-Y., and V. Gallien. 2009. Plague immunodetection in remains of religious exhumed from burial sites in central France. *Journal of Archaeological Science.* 36: 616-621.

Bowsky, M. 1964. The impact of the Black Death upon Sienese government and society. *Speculum*. 39(1): 1-34.

Cohn, S.K. 2002. The Black Death: end of a paradigm. *The American Historical Review*. 107(3): 703-738.

Dewitte, S.N., and J.W. Wood. 2008. Selectivity of Black Death mortality with respect to pre-existing health. *Proceedings of the National Academy of Sciences of the United States of America*. 105(5):1436-1441.

Gowland, R.L., and A.T. Chamberlain. 2005. Detecting plague: palaeodemographic characterization of a catastrophic death assemblage. *Antiquity*. 79: 146-157.

Grainger, I., Hawkins, D., Cowal, L., and R. Mikulski. 2008. *The Black Death cemetery, East Smithfield, London.* Museum of London Archaeology Service. MoLAS Monograph 43.

Jessee, E. and M. Skinner. 2005. A typology of mass grave and mass grave-related sites. *Forensic Science International*. 152: 55-59.

Kacki, S., Rahalison, L., Rajerison, M., Ferroglio, E., and R. Bianucci. 2011. Black Death in the rural cemetery of Saint-Laurent-de-la-Cabrerisse Aude-Languedoc, southern France, 14th century: immunological evidence. *Journal of Archaeological Science*. 38: 581-587.

Milner, G.R., Wood, J.W., and J.L. Boldsen. 2008. Advances in Paleodemography, pp. 561-600 in M.A. Katzenberg and S.R. Saunders (eds.) *Biological Anthropology of the Human Skeleton*. 2nd edition. New York: Wiley-Liss.

Müller, H-G.,Love, B., and R.D. Hoppa. 2002. Semiparametric method for estimating paleodemographic profiles from age indicator data. *American Journal of Physical Anthropology*. 117: 1-14.

Noymer, A. 2007. Contesting the cause and severity of the Black Death. *Population and Development Review*. 33(3): 616-627.

O'Shea, J.M. 1984. Mortuary Variability: An archaeological investigation. New York: Academic Press.

Paine, R.R. 2000. If a population crashes in prehistory and there is no paleodemographer there to hear it, does it make a sound? *American Journal of Physical Anthropology*. 112: 181-190.

Perera, C. and C. Briggs. 2008. Guidelines for the effective conduct of mass burials following mass disasters: post-Asian tsunami disaster experience in retrospect. *Forensic Science Medical Pathology*. 4: 1-8.

Raoult, D., Aboudharam, G., Crubezy, E., Larrouy, G., Ludes, B., and M. Drancourt. 2000. Molecular identification by "suicide PCR" of *Yersinia pestis* as the agent of Medieval Black Death. *Proceedings of the National Academy of Sciences*. 97(23): 12,800-12,803.

Signoli, M., Ardagna, Y., Adalian, P., Devriendt, W., Lalys, L., Rigeade, C., Vette, T., Kuncevicious, A., Poskiene, J., Barkus, A., Palubeckaite, Z., Garmus, A., Pugaciauskas, V., Jankauskas, R.,

and O. Dutour. 2004. Discovery of a mass grave of Napoleonic period in Lithuania (1812, Vilnius). *Comptes Rendus Palevol. 3*: 219-227.

Tran, T-N-N, Fozzato, L., Aboudharam, G., Raoult, D., and M. Drancourt. 2011. High throughput, multiplexed pathogen detection authenticates plague waves in Medieval Venice, Italy. *PLoS ONE*. 6(3): 1-5.

Wood, J.W., Milner, G.R., Harpending, H.C., and K.N. Weiss. The Osteological Paradox: problems of inferring prehistoric health from skeletal samples. *Current Anthropology*. 33(4): 343-370.