Work and the adolescent in medieval England (AD 900-1550): the osteological evidence

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Work and the Adolescent in Medieval England (AD 900-1550). The osteological evidence.

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ABSTRACT

WHAT WAS IT LIKE TO BE A TEENAGER IN MEDIEVAL ENGLAND? Despite the fact that medieval society often singled young apprentices and workers out for comment, their study has been largely neglected in medieval archaeology. The skeletal remains of 4940 adolescents (6.6-25 years) from 151 sites in medieval England was compiled from a combination of primary data collection and secondary data from published and unpublished skeletal reports and on-line databases. The aim was to explore whether apprentices could be identified in the archaeological record and if so, at what age they started work and what impact occupation had on their health.

The data were divided into urban and rural groups, dating from before and after the Black Death of AD 1348-9, and before the Industrial Revolution. A shift in the demographic pattern of urban and rural adolescents was identified after the Black Death, with a greater number of young females residing in the urban contexts after 14 years. The average age of males increased from 12 years to 14 years after the plague years, contrary to what we might expect from the documentary sources. There were higher rates of spinal and joint disease in the urban adolescents and their injuries were more widespread than their rural counterparts. Domestic service was the potential cause of the greater strain on the knees and backs of the urban females, with interpersonal violence evident in the young urban males. Overall, it was the urban females that carried the burden of respiratory and infectious diseases suggesting they may have been the most vulnerable group. This study has demonstrated the value of adolescent skeletal remains in revealing information about their health and working life, before and after the Black Death.

KEYWORDS

apprentices, osteology, fractures, infection, mortality, joint disease, male and female

Over the past 20 years there has been increasing interest in the historical aspects of childhood,[i] the life course[ii] and apprentices,[iii] but until now there has been little archaeological contribution to these debates. An 'archaeology of childhood' has emerged[iv] but has tended to focus on infants and younger children. Despite the wealth of evidence for medieval skeletons that exist in England, this will be the first attempt to use these data to view life during the transitional period of adolescence. This study explores the health of older children and adolescents (6.6-25 years) in medieval England between AD 900-1550, collating published and unpublished osteological reports, palaeopathological case studies and historical evidence. The aim is to explore what it was like to be an adolescent in the medieval period before the Industrial Revolution, and to examine the impact of work on their health. Individuals aged up to 25 years were included in this definition of 'adolescent' as this it conforms both to modern clinical practice,[v] and the medieval religious concept of 'adolescentia' or 'Iuuentus' (21-28 years). Among the lay population, the ever extending

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period of indenture for apprentices meant individuals may have been 25 years old before they were considered independent 'adults'.[vi]

Attempts to provide an overview of the health of individuals living in medieval England using our vast osteological archive are surprisingly rare. Mays[vii] concentrated on religious orders in his review of medieval adult palaeopathology. Roberts[viii] was one of the first to examine general health and welfare using data from 135 sites, and an unprecedented 23,359 adult skeletons. She concluded that people from the early medieval rural contexts were healthier than those living in later medieval urban environments. Roberts took a novel approach by analysing diseases within contextual themes; the living environment (sinusitis, rib lesions, rickets, cribra orbitalia), economy and diet (scurvy, hypoplasia, diseases of excess (DISH, gout)) and access to healthcare (trepanation, amputation). However, age, sex and individuals under 17 years were not included in the analysis. More recently, DeWitte et al.[ix] explored mortality in adult males from medieval monastic and non-monastic cemeteries in London. Their data comprised 896 male adults aged 18-45+ years and indicated that males within the religious houses had a better chance of survival, perhaps due to a better monastic diet and selective recruitment of healthier males into their Orders.

Isolated attempts to identify possible apprentices in osteological samples have been carried out previously. In her analysis of the remains from the sunken warship Mary Rose, Stirland[x] identified 18 individuals aged 10-18 years, with the majority of the crew made up of 18-25 year old males (n=54). These young men had a series of occupational changes to their bones, including leg and nasal fractures, severe arthritis of the elbow, and six cases of avulsion fractures of the knee, or Osgood-Schlatter's disease. Today, these lesions are generally found in boys aged 12-14 years who put undue pressure on their developing knees, usually as the result of excessive sport, jumping and kneeling.[xi] The high prevalence of these lesions in this group suggests a strenuous lifestyle. One 12-15 year old had lesions in their spine that suggested they carried heavy loads (Schmorl's nodes). The remains were found in the area where the gun crew would have been situated when the ship sank, and Stirland[xii] suggests this child might have been a powder monkey. Later, Walker[xiii] argued that a 12-17 year old adolescent with severe frontal sinus infection at St Mary Spital, London could have acquired the condition as the result of their work as an apprentice.

THE MEDIEVAL ADOLESCENT AT WORK

Much of the documentary information about the working lives of children in the medieval period is related to wealthier families who could afford to pay the required fees to secure an apprenticeship. Children from poorer families would have travelled to urban areas to seek employment in less secure circumstances, and perhaps at a younger age, as menial workers and domestic servants. For these individuals we rely on the skeletal data to give us an insight into their lives. Dunlop[xiv] was one of the first historians to explore the origins of apprenticeship. Before the 12th century the majority of labour was agricultural, and children would have worked through agreement with an overlord. Urban areas were small and foreign trade was limited.[xv] The earliest reference to an apprentice is recorded in the Ordinance of London Lorimers in 1261, which fixed the term of service at 7 years and prohibited one master from enticing an apprentice ('apprenticis') away from another. The need for such regulations to be written down suggests that the practice was around earlier, but was evolving from an informal and local custom to a national concern.[xvi] By 1300, there was a Common Council of the City Act to deal with enrolment of London apprentices. By the

fifteenth century, a system of technical training had developed and Guilds were introducing their own rules. For example in AD 1498, the Ironmonger's Guild established a bylaw on dress and required that an apprentice's hair should not be worn too long.[xvii] Michaud[xviii] examined child labour in France using over 1000 contracts from AD 1277-1400 from Marseilles, before and after the Black Death. These contracts identify a group of 'young workers' who hired themselves out to a master in order to learn an art. There is no mention of such a practice in the English records, but then only 19 apprentice contracts have survived.[xix]

Bitel[xx] argued that economic growth in the eleventh century encouraged men and women to move to town for work. They were not crowded cities, and only London had a population of more than 10,000.[xxi] After the plague, historians have a better record of who migrated and at what age. For instance in York during AD 1357-1507, most of the women who migrated to urban areas were in their late adolescence and only moved to towns within one day's travel from their home.[xxii] They were able to escape old agricultural ties and explore new occupations, but they were often short term migrants, and many later returned home to take up farm work and marry.[xxiii] Goldberg[xxiv] suggests after the Black Death, female movement was more variable than the males, who may have been tied to an apprenticeship. Women would take casual, annual work and move around more frequently gaining more freedom and independence.

The wealthy classes generally gained apprenticeships as grocers, drapers, haberdashers, mercers and merchant tailors, taking advantage of England's extensive international cloth trade, as well as the more lucrative crafts such as gold working and ship building.[xxv] For these trades, the cost of an apprenticeship was high, reflecting their advantageous position. Children of husbandmen, labourers and craftsmen tended to enter smaller metal, leather and wood crafts such as coopers and hosiers, felt makers and weavers, carpenters, farriers, and smiths, or enter the growing building industry.[xxvi] Although smaller, premiums were still paid for lesser craft apprenticeships, and may have been a barrier to the very poor migrants entering the urban centres.[xxvii] Adolescents may have worked odd jobs or in agriculture until they could save up enough to enter an apprenticeship themselves. By the sixteenth century, apprentices could be employed after a payment of several hundred pounds for entry into one of the 12 Great Companies,[xxviii] or taken on basis of room and board, allowing poorer families to take advantage of the scheme. Orphans may have found a position through the Justice of the Peace or Overseers of the Poor.[xxix]

Before the Black Death there were no limits on how many young people a Master could have under contract.[xxx] After the Black Death, and to protect agricultural output, a rule was enforced that any child who had worked on the land up to the age of 12 years could not leave it for an urban craft (c.AD 1507). Deformity, foreign birth, and bastardry were also barriers to apprenticeship.[xxxi] Guilds began to limit the age at which boys could become apprentices, only allowing sons of craftsmen to enter the same trade, and limiting the number of apprentices taken. By 1498 some Guilds had extended the years of service from 7 to 10.[xxxii] The drop-out rate of apprentices was considered to be around 50%, with 10-20% dying during their indenture.[xxxiii] Between AD 1350-1360, 49 runaway apprentices were recorded in London. The death of the Master may have ended the apprenticeship, and would have resulted in financial hardship if the apprentice's contract was not sold on.[xxxiv]

MIGRATION

Thrupp[xxxv] analysed apprentice, poll tax and surname records dating from AD 1319 and demonstrated that London's expansion before the Black Death relied mostly on migration from the southern counties, the midlands and the north. Hovland[xxxvi] suggests 75-82% apprentices goldsmiths came from outside London. After the Black Death, York attracted 42% of migrants from a 20-mile radius, as labour shortages due to plague deaths provided new opportunities for women and children to gain employment and increase the family income.[xxxvii] Tithing rolls from Essex dating to AD 1350-1525 included migrant men aged 12 years and older.[xxxviii] Wareing[xxxix] estimated that during AD 1486-1500, 51.4% of people whose origins were known came to London from the Northern counties. In England, children between the ages of 7 and 14 years migrated to the towns looking for an apprenticeship,[xl] and women became domestic servants for the new middle classes.[xli] Poorer members of society and immigrants were attracted to the suburbs, initially located outside the town's defences, where polluting industries were placed to limit potential fire hazards and air pollution.[xlii] Penn and Dyer[xliii] suggest that in the late fourteenth century, the average distance tradesman migrated was about 7 miles, with one roofer travelling 24 miles to find work. Most of these migrants were in the building trade. By the mid-sixteenth century, around 90% of London's apprentices were migrants.[xliv] These young apprentices would have been a visible and sizable presence in the city. By contrast, in Bristol the proportion of apprentices was about 10%, with around 200-230 apprentices entering Bristol every year and in smaller towns this figure may have only been 5%. Accounts demonstrate the strange sights and unfamiliar environment the migrants from villages encountered, and that many travelled by rivers and roads, or sea without securing a place to live or a master to apprentice them.[xlv] Kendall et al.[xlvi] were the first to examine the pattern of migration in later medieval London using stable isotopes of oxygen and strontium ratios from the East Smithfield's plague cemetery (AD 1348-1350). Five individuals out of the 30 they sampled (17%) had oxygen values that put them outside the biosphere of London, such as Devon, Cornwall, York, Wales and Scotland. Roberts et al.[xlvii] examined the origin of people from medieval Hull buried at Blackfriars in the 14-16th century using oxygen and strontium. They sampled 12 individuals, including a 17-25 year old male with syphilis. Strontium suggests he may have come from Scottish highlands, or even Sweden.

The Age of the Apprentice

Prior to the Black Death apprenticeships for boys are thought to have begun between the ages of 14-16 years, with girls entering service earlier, sometimes by the age of 10.[xlviii] This age rose to 18 years by the late fifteenth century.[xlix] The duration of service also gradually increased, meaning that by the fifteenth century, individuals may have been 28 before they were considered 'adults'.[l] Goldberg[li] found domestic servants in York were aged between 11 and 23 years during AD 1357-1507. In France, boys aged 12 years and girls aged 14 years could become apprentices, with the average age of 16.5 years.[lii] The youngest recorded apprentice was a girl signed to a weaver at the age of 12. After the Black Death, the average age of apprentices and other young workers dropped by about three years to 13.8 years with the youngest child aged 6 years, but the majority were still aged between 12-16 years. Not surprisingly, a greater number of orphans joined the work force, with 4 in 5 young workers recorded as orphaned or fatherless.[liii] Ben Amos[liv] argued that orphans from poor families would be apprenticed at 10 years whereas wealthier orphans may be apprenticed at 13 years. Girls tended not to collect a wage and worked more in return for food and

board, shoes and clothing. They entered domestic service between 6-14 years of age, with an average age of 10; boys entered domestic service aged 10-12 years, with an average age of 15.[lv] In England, Towner and Towner's[lvi] study of the Sussex Coroner's inquests from AD 1485-1688, listed boys' jobs and ages as: carter (9-13 years), sailor (13 years), and ploughman (11 years). Alexandre-Bidon and Lett[lvii] question the age of 12 as being the real age at which apprentices started work, as the actual age was more likely to be determined by individual family circumstances and the ability of the child. However, 12 years has been argued to signal the end of a child's growth period, and John Paston (AD 1465) commented that: "every poor man who has brought up his children until they reached 12 years of age usually finds that, at this age, they can be of some use to him."[lviii] It should be remembered that medieval societies did not record actual birthdays, and so any age assigned to a child should be considered a rough estimate based on the child's mental and physical maturity. For example, in the 12th century, Cluniac orders placed the period of 'adolesencia' much older at 15 years, and this was also considered the time at which boys matured. Recent osteological research supports this later age of pubertal development, with the skeletal signatures of peak maturation not appearing in medieval males from London and York until 15-16 years, and females not achieving menarche (i.e. their first period), and hence fertility until around 14-15 years.[lix]

Health and Well-being

Apprenticeships were established through a formal contract and registered with a Guild and the city of London. The contract outlined the behaviour required[lx] with the apprentice pledging not to marry or fornicate, to avoid drinking and gaming and going to theatres, not to gossip about the master or spend the master's money.[lxi] Corporal punishment was expected as a form of discipline. If the apprentice ran away, their sponsors were fined and the apprentice was barred from the craft. Before the Industrial Revolution, it was likely that the working day was 5am to 8pm depending on the hours of daylight, and no concession was made for the age of the apprentice.[lxii] Servants had a different relationship: their contracts were of shorter duration, and the difference in the status and age between servant and employer was greater.[lxiii]

Most of the complaints by apprentices were about being asked to carry out menial tasks, not being released at the end of their apprenticeship, or not being trained properly. In 1317, two male apprentices took their master and his wife to court complaining that the master was not around enough to train them, and the wife beat them so badly that one of them had lost an eye. A medical examination proved the point.[lxiv] There are also records of female apprentices being beaten with sticks and knives, and of mistresses 'hiring out' their female apprentices to men. Barron's[lxv] examination of the 19 indenture records dating from the 1250s-1530s relates a real concern for the welfare of child workers. For example, in 1398 there was a ruling that apprentices, journeymen and young children could not be sent down to 'scour caps' on the Thames, because they got into fights and that it was scandalous that they should be forced to work in 'tempests, frosts and snows'. A young boy who stuffed a goose with feathers and parsley to use as a pillow was considered too young to have been beaten by his Master, who was promptly sent to Newgate for eight days for mistreatment.[lxvi] Spindler[lxvii] cites John Bartlett's' unnamed son, who after 10 years was sold by his first Master and then sold again, until he was mistreated by his third Master, starved and left freezing. When John came looking for his son a full 19 years later, he took the case to court. Spindler[lxviii] however, criticises the use of legal documents alone to examine the

welfare of apprentices as they can exaggerate the extent of disputes. Accidents at work were more common. Gordon[lxix] looked at accounts of medieval English saints and martyrs AD 1170-1500. While treated with caution, the records do show that of the 76 accounts of drowning, 10 involved children at work. One domestic servant in Norwich in AD 1274 leant forward to retrieve her bucket when the cord broke and the weight dragged her to the bottom of the pool.[lxx] Towner and Towner[lxxi] discovered nine coroner's records of children who had accidents at work in the 8-13 years age group. For example, one 12-year-old girl drowned while fetching water as a servant in an Inn, another aged 14 years drowned washing linen in a river.

Spindler[lxxii] considered the start of an apprenticeship as a destabilising moment for a child, removed from their family with whom they often lost all contact. Entrance into a new environment carries high risks of disease and death for the migrants, due to their lack of adaptation or exposure to diseases, or the stimuli that make up that environment.[lxxiii] In fact, in seventeenth century London, apprentices from the countryside were notorious for contracting smallpox as soon as they arrived in the city.[lxxiv] When an apprentice suffered mental illness or injury, parents retrieved them and they may also have been taken home in times of plague.[lxxv]

Ben-Amos[lxxvi] examined the concept that apprentices developed a medieval 'youth culture'. It seems that they did behave as a group, socialise with their peers and have their own attitudes towards dress and identity. Certainly there were disputes about apprentices' dress, with laws that they could only wear the clothes provided by the Master, and could not wear lace, velvet or embroidery.[lxxvii] There were apparent on-going battles with regards to hairstyles with apprentices marched to courts to have their head shaved when their hair was deemed too long, and rulings that apprentices were not to wear a wig over 15 shillings (or £335 today).[lxxviii] Contemporary rhetoric suggests that groups of apprentices in a social setting were unruly and dysfunctional. Masters and wardens of craft guilds joined together to prevent 'riots' of their servants and apprentices.[lxxix] In July 1417, civil unrest showed apprentices to be politically engaged and a threat to public order, but it has also been suggested that youths were often drawn into political battles at times when they had gathered informally and spontaneously (i.e. to eat lunch).[lxxx] Examples of vandalism include Richard Waltham who with a group of friends, broke windows and damaged lead pipes in Friars Minor. In St Paul's churchyard, a youth (pueri) started a war game that ended in a riot. In 1414, boys were forbidden to play team games that may start a fight. Whatever the cause, it seems fighting was a common activity among the urban male youths, but they are also known to have spent their leisure time playing football and dancing. Unemployed poor youths were involved in petty crime, vagrancy and theft and Bridewell prison boasted a number of runaway apprentices.[lxxxi]

As for the females, Bitel[lxxxii] argues that only midwives would have had a formal apprentice, while the rest learned their trade as domestic servants from the adult females in the household. After the plague years, women sought new forms of employment, married later and had fewer babies resulting in a demographic decline. Women were associated with the food and drink industry, as brewers and spinners, but are also mentioned as being among the common labourers.[lxxxiii]

Skeletal remains of children are available for all counties in England and a variety of different sites, including religious communities such as friaries, priories and nunneries; schools, castles, hospital sites, mass graves, execution sites and urban and rural lay cemeteries. Skeletal evidence provides us with the opportunity to examine the experiences

of those living in towns or the countryside; did males and females share a similar quality of life? What impact did the Black Death (AD 1348-9) have on the age at which children began work, and their movement into the towns? The examination of skeletons from cemetery sites has the advantage of allowing us to determine the health of these young workers from all sections of society and, for the first time, determine who they were (i.e. sex and age) and how they lived.

MATERIALS AND METHODS

Skeletal data from sites across England were drawn from published and unpublished osteological reports, or downloaded from the Archaeological Data Service (ADS) including Gilchrist and Slone's Requiem Project database,[lxxxiv] the Museum of London's Archaeological Services Centre for Bioarchaeology's online Wellcome Osteological Database (WORD), or from commercial archaeological units. A total of 151 sites dating from AD 900-1550 were available. Of the 4940 skeletons included in the analysis, 31.3% of these data (1549 skeletons) were collected during this study. It is likely that the results are heavily biased towards individuals from the large cemeteries of medieval London, which contributed 1458 or 29.5% of the skeletal data (See Tabs A1a-c for site details).

Individuals were divided into four main age categories: 6.6-9.9 years, 10.0-13.9 years, 14.0-16.9 years, and 17.0-25.0 years. Children between 6-10 years were included in the study as some historical literature suggests 7-8 years may have been the earliest age at which children could start work. The second and third age categories span the start of the puberty growth spurt and after 14 years, the physical changes such as increased musculature, beard growth and menses that may have signalled a change in status or society's perception of the individual.[lxxxv] Reports date from the 1930s to the present day, and ages assigned to the individuals and the reporting of pathology varies between each report. For example, the age ranges used for older children and young adults varied considerably between authors (e.g. 20-30; 15-20, 12-17 years) making it difficult to assign each individual to a specific category. In order to assign the ages as evenly as possible, where an age range was assigned in the report that spanned the range designed for the current project, the age at the mid-point of the category was calculated, and that age was used to assign the individual to a category (i.e. the mid-point for 12-17 years is 14.5 years, and the individual was assigned to the 14.5-16.9 year age category, the same was the case for individuals described as 11-16, 13-17, 15-20 and 16-19 years). Those described as 'adolescents' (n=12) were also assigned to this group. In many cases, individuals were only referred to as 'young adult' or described as '18-25 years' and were assigned a standard 17-25 year age classification.

In many reports, there was a noticeable lack of individuals assigned to the 17-25 year age brackets compared to high numbers of 'adults', a term assigned to individuals that are too poorly preserved for age and/or sex estimations to be made. For example, at the lay cemetery of St Mark's Church in Lincoln,[lxxxvi] there were 74 'adults' comprising 25% of the total adult sample, but only four individuals aged 17-25 years. Late fusing epiphyses (i.e. the sternal end of clavicle, S1) used to identify an individual as a 'young adult' are less likely to survive than the features of mature age such as osteoarthritis, meaning that it is likely many more young adults are consigned to the 'adult' age category than any other age group.

To simplify the sex categories, individuals referred to as '?M' or '?F' in the reports were assigned male or female. In the 10.0-13.9 year age group, the sex of the individual was taken when stated in the osteological report for individuals over the age of 12 years (55

males; 38 females). Although the use of definitive males and females is always preferable, it was felt that data on male and female exposure to pathology and trauma warranted the inclusion of less securely sexed individuals. The collection of primary data for this study identified 130 sexed individuals in the 10.0-13.9 year age category (69 males and 61 females) and 282 sexed individuals in the 14-17 year age category (175 males, 107 females). While sex determination in individuals younger than 14 years is problematic as they do not show the secondary sexual characteristics that appear at puberty, several methods show an improvement in accuracy after the age of 10 years, especially for the ilium.[lxxxvii] Only traits reported to have 70% accuracy or over were employed and included features of the ilium (sciatic notch angle (72%), sciatic notch depth (81%), auricular elevation (72-85%); the humerus (trochlear symmetry (81.5%), olecranon fossa shape (85%), medial epicondyle angle (78%); and mandible (chin prominence (73%)).[lxxxviii] By the age of 14 years, the pelvis begins fusion and estimations of sex based on pelvis morphology and the fused distal humerus become more secure, although many of the cranial features are still fairly effeminate.[lxxxix]

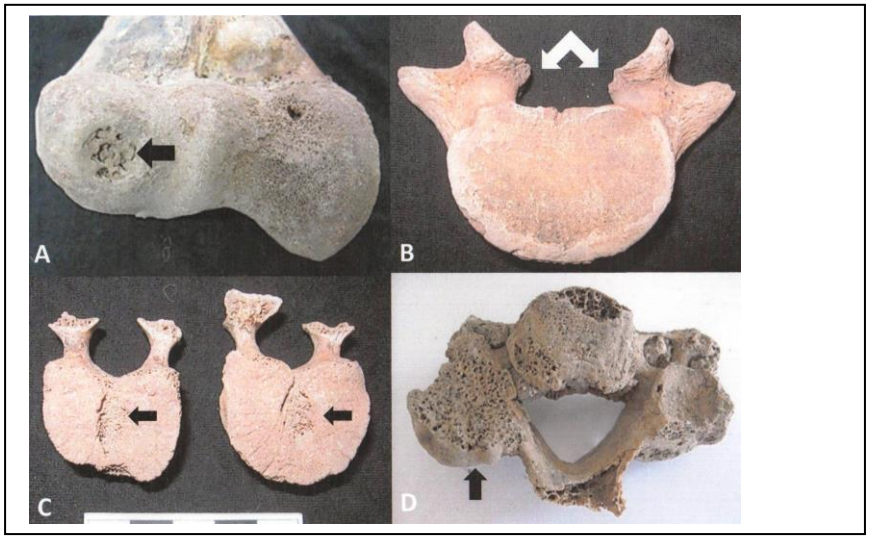
Sites were divided into urban and rural settlements, and where archaeological dating allowed, into pre- (AD 900-1348) and post- (AD 1349-1550) Black Death. This was done in order to discern any changes in adolescent mortality and health during a period when population movement and employment law underwent significant transition.[xc] The Reformation of the late 1530s had a major impact on health and health care practices of medieval society,[xci] but it was rarely possible to identify individuals buried in the last 20 years of a cemetery's use at sites dated up to the 1550s. Hence, some post-medieval individuals may be present within the sample, although this number is likely to be small. There were 47 rural sites and 104 urban sites in the study, and 87 sites had individuals that could be identified as being buried either pre- or post-Black Death, with 15 of these sites having individuals from both periods (Tab A1a-b). The disparity in the number of individuals from each context (880 rural and 4060 urban; 2608 pre and 516 post Black Death) will have some impact on the interpretation of the results (Tabs 1 and 2).

PATHOLOGY

The detail of palaeopathological data provided in each report was expectedly patchy, with some devoting more time to pathological descriptions than others. Where descriptions were too vague to allow for a confident diagnosis the pathology was not included. Disease of every classification outlined in Roberts and Manchester[xcii] were identified in the sample. Following Roberts[xciii] the conditions were divided into contextual groups, and as the current study is interested in exploring occupational stress in the adolescents, these were broadly defined as: infections (periosteal new bone formation, osteomyelitis, osteitis, endocranial lesions, treponemal disease and leprosy); trauma (long bone and rib fractures, head injuries, limb paralysis); respiratory diseases (sinusitis, visceral rib lesions, tuberculosis) and stress to the joints and spine (osteochondritis dissecans, spondylolysis, clay-shoveler's fractures, Schmorl's nodes and osteoarthritis). This final category is unique to the study of occupational stress and warrants further explanation.

Osteochondritis dissecans (OCD) involves the fragmentation of the cartilage and possibly the underlying bone, with trauma being the main contributing factor, although developmental defects of cartilage should be considered.[xciv] The onset is usually in adolescence and today, it is more common in males than females. There is known to be familial occurrence, but the main aetiology is repetitive trauma to the affected area due to

vigorous activity.[xcv] The knee is affected in around 90% of cases, most frequently on the lateral condyle and it occurs more on convex surfaces. After the distal femur, the elbow, ankle, hip, shoulder and wrist are most commonly affected in that order.[xcvi] OCD of the knee has been demonstrated to be more common in 12-19 year olds than 6-11 year olds.[xcvii] There are joint defects that may be confused with OCD especially when they occur on the concave areas of the joint (base of the first metatarsal or big toe), and a porous well-defined margin is needed to diagnose it correctly. It is likely that some of the lesions recorded in the accumulated data were wrongly diagnosed (Fig. 1A).



Examples of pathological lesions used to infer occupational pathology.
(A) osteochondritis dissecans of the right distal humerus in an 18-year-old female from St Mary Spital, London (reproduced by kind permission of the Museum of London Archaeological Service), (B) spondylolysis of the fifth lumber vertebra in a 16-year-old female from Barton-on-Humber, Lincolnshire (C) Schmorl's nodes in a 17-year old male from Barton-on-Humber, and (D) osteoarthritis of the neck, probably secondary to trauma. Note contour change of the right inferior facet of the 3rd cervical vertebrae in this 18-year-old male from St Oswald's Priory, Gloucester.

Spondylolysis is classed among stress fractures despite reflecting a possible congenital weakness in the spine.[xcviii] Spondylolysis describes the partial separation of the inferior facets on the neural arch from the vertebral body that occurs between the ages of 10-12 years (Fig. 1B). The condition results from microtrauma in low grade stress on the lower back as the result of bending and lifting strains, or a fall from a height.[xcix] This fracture most commonly occurs on the fifth lumbar (L5) vertebra (at the base of the spine) at any point after a child begins to walk. The normal occurrence of the lesion in a population is around 6-8% rising to 63% in individuals involved in certain sporting activities.[c] Clay-shoveler's fractures are avulsion fractures of the tip of the spinous process in the spine, rarely seen in children. Reported cases involved a teenage wrestler and baseball player, suggesting excessive weight bearing and torsion on the ligaments of the mid back are a causative factor.[ci]

Schmorl's nodes are common often asymptomatic depressions caused by herniation of the nucleus pulposus on the superior and inferior surfaces of the vertebral bodies (Fig. 1C). Their aetiology is complex, although spinal trauma caused by vigorous activity and flexion and extension of the spine is most commonly associated with their formation.[cii] The age of their occurrence is not clear, but they generally appear before the age of 18 years.[ciii]

Plomp et al.[civ] argued that males are more susceptible to these lesions due to the size and shape of their vertebrae. The prevalence of Schmorl's nodes is reported as being from 5% to 76% in archaeological samples.[cv]

Osteoarthritis, or degenerative joint disease, is a common finding in archaeological samples (Fig. 1D). It is identified when a combination of lesions is present: marginal osteophytes (bony projections), porosity, joint contour change (i.e. flattening and expansion) and polishing (eburnation). The latter is the end stage of osteoarthritis.[cvi] Osteoarthritis has a complex aetiology, but normally develops with age and is rare before the fourth decade of life.[cvii] However, excessive mechanical loading on a joint through habitual use, and trauma can predispose to early onset arthritis.[cviii] Lovell[cix] noted spinal degenerative changes in individuals as young as 21-30 years (26% of joints) in her Bronze Age population from the Indus valley, now Pakistan, citing carrying loads on the head and dragging heavy objects as potential causes of neck and lower back arthritis in the population. To date no research has been carried out on the prevalence of degenerative arthritis in medieval adolescent skeletons.

RESULTS

The total sample comprised 4940 aged individuals derived from 151 sites in England, of these 2302 (46.5%) were assigned a sex with 1400 (60.8%) males and 902 (39.1%) females (Tab 1). The majority of skeletons (n=2757, 55.8%) came from lay cemeteries with 82.1% of the total sample coming from the urban areas. When divided into pre- and post-Black Death categories, of the total 3124 individuals, only 16.5% (n=516) dated to after the Black Death. In total, 879 males and 617 females were represented in this part of the analysis, with 82.3% of the sexed individuals coming from sites dated before the Black Death (Tab 2). Skeletal pathology was recorded in 4612 individuals and 109 of the 151 site reports (Tab 3). Of these, 86.3% were urban (n=3983) and only 13.6% were from rural (n=629) contexts. In order to account for the much larger numbers in the urban sites each, pathology was calculated as a percent of the number of individuals in each context (a crude prevalence rate), and by age and sex. Differences were tested for statistical significance using a non-parametric Pearson's chi-squared test (X^2). To avoid the risk of Type 1 error (false-positives), tests were only carried out when the percentages suggested the results were very different, and the confidence interval was set at 95% (P=0.005).

DEMOGRAPHIC PROFILES

The overall demographic profile showed a relatively even proportion of adolescents within each age group in the urban and rural sites, with males predominating. There are marginally more 14.0-16.9 year olds in the urban contexts and 17-25 year olds in the rural sites (Tab 1, Fig. 2). When the sites were divided into pre- and post-AD 1348 (Tab 2, Fig. 3), there were significantly more 14.0-16.9 year olds in the urban contexts before the Black Death than in the rural sites at 17.8% (n=383/2151) compared to 8.7% (n=40/457) respectively (X^2=22.73, P=0.001, 1 d.f.). The paucity of 14.0-16.9 year olds in the pre-Black Death rural contexts is highlighted by double the number of 10.0-13.9 year olds in this group at 19.6% (n=90/457) (X^2=22.42, p=0.001, 1.d.f.). Those in the 17-25 year old age group made up the majority of the sample in both the urban and rural contexts, but more of these older adolescents resided in the rural areas forming just over half of the population in both periods (53.2% and 51.0% respectively). Before the advent of the Black Death, this number is significant when compared to the urban population (pre-1348: X^2=11.94, P=0.001). One of the most striking

differences following the Black Death is the significant drop in 6.6-9.9 year olds in the rural contexts from 18.3% (n=84/457) before the epidemic, to just 7.1% (n=7/98) (X^2 = 7.43, P=0.005, 1.d.f.). But, while numbers of 6.6-9.9 year olds in the urban centres rose slightly from 16.6% to 21.0% , this was not significant (X^2 = 4.74).

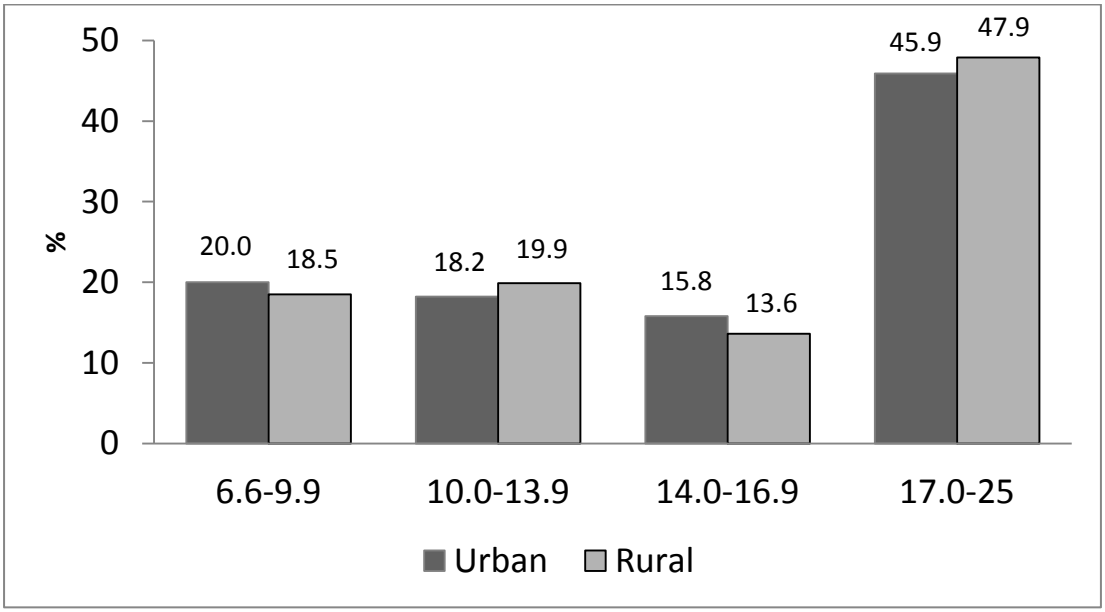


FIG 2. Percentage of urban and rural individuals in the study sample, by age group

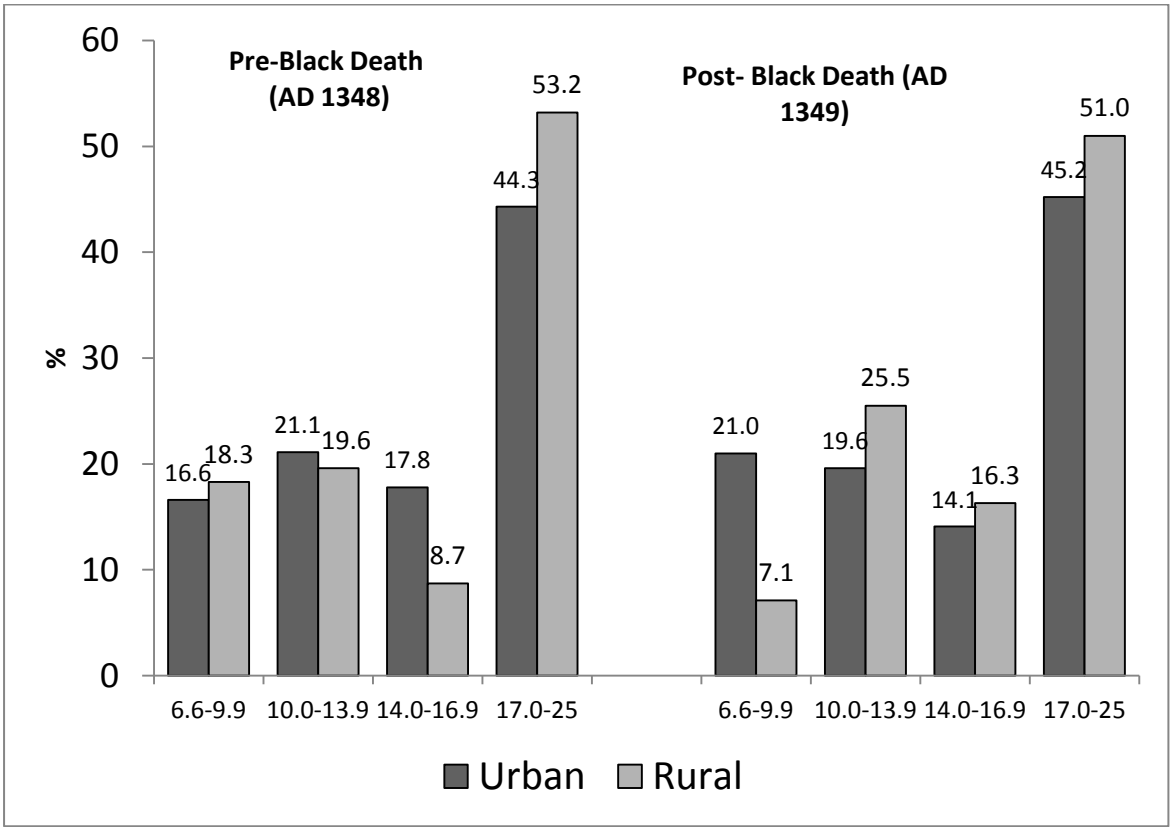


FIG 3. Percentage of individuals from urban and rural contexts, before and after the Black Death

When the data is divided into males and females (Fig. 4), after the Black Death there is a slight rise in the number of 14.0-16.9 year females in the urban context from 14.1% (n=61/433) to 19.7% (n=15/76). Conversely, the number of urban males of the same age drops from 21.0% (n=126/598) to just 12.4% (n=17/137). However, number of individuals derived from the pre-Black Death cemeteries are low (n=418 urban individuals) and none of these patterns are statistically significant.

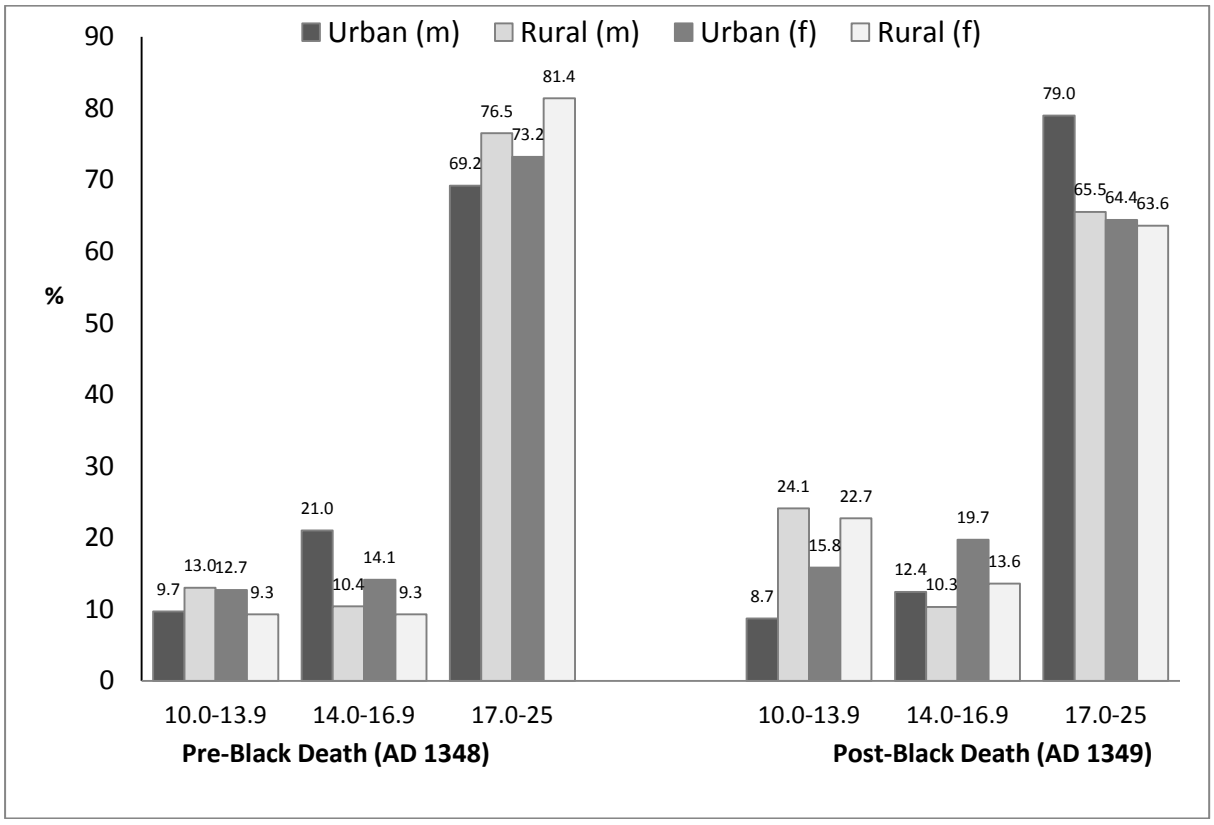


FIG 4. Percentage of males and females in the study sample

INFECTIONS (NON-SPECIFIC INFECTIONS, ENDOCRANIAL LESIONS, TREPONEMAL DISEASE AND LEPROSY)

The identification of infections in past skeletal remains relies on the individual's survival for long enough to allow the disease to become chronic, the development of characteristic lesions enabling one infection to be distinguished from another and, good preservation of the skeleton. For that reason, percentages reported here should be considered an underrepresentation of the actual disease burden experienced by these medieval teenagers. The total prevalence of infections between the urban and rural sites was slightly higher in the urban groups compared to the rural at 11.4% (n=454/3983) and 8.9% (n=56/629) respectively. The most commonly recorded condition was periosteal new bone formation (n=385, Tab 4), which results from inflammation of the periosteum as the result of infection, but may also indicate minor trauma to that area. For the purposes of this study, periosteal new bone formation was taken as an indication of an infection, unless other changes were present to suggest a different aetiology (e.g. evidence for vitamin C deficiency or scurvy). Infections rose steadily with age in the urban contexts, but appeared to decline between 10.0-13.9 years and 14.0-16.9 years in the rural group (Fig. 5). However, no differences were

statistically significant. When examined by sex overall (Tab 5), urban females suffered from significantly more infections than their rural counterparts (X^2 =12.11, P=0.001, 1d.f.), with both groups showing a peak in infections at 14.0-16.9 years of age. Of the specific infections, there were 12 cases of treponemal disease, with seven sexed individuals. Only one rural male was affected and of the six sexed cases in the urban sites, five were females, two aged between 14.0-16.9 years. There were 72 cases of leprosy in the urban sites compared to only four cases in the rural context, probably reflecting the greater number of leprosaria excavated in urban sites. The overall difference between urban and rural leprosy was not significant (1.8% and 0.6% respectively). Of the 34 sexed leprosy cases, males were most commonly affected (n=23 males, 11 females) with the youngest a male aged 10-13 years.

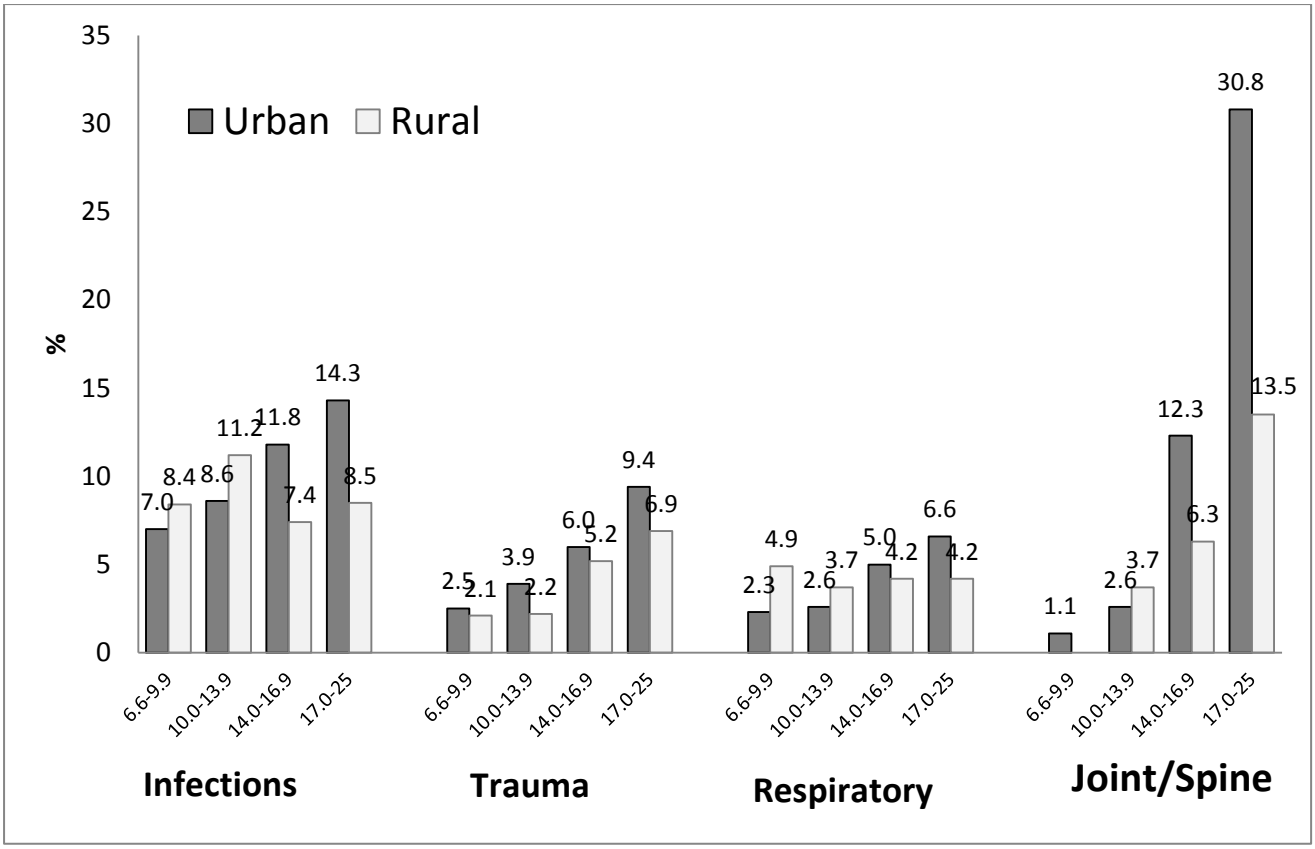


FIG 5. Crude prevalence rate (%) of occupational disease by age and site type

TRAUMA (LONG BONE AND RIB FRACTURES, HEAD INJURIES, DISUSE ATROPHY)

The overall crude prevalence rate of trauma in the urban and rural groups was 6.4% (n=258/3983) and 4.6% (n=29/629) respectively (Tab 4). In both samples, trauma increased gradually with age, and this is the expected clinical pattern where the longer you live the more likely you are to be exposed to trauma. When male and female rates were compared (Tab 5, Fig. 6), urban males had a higher prevalence than their rural counterparts with 12.8% (n=144/1125) compared to 4.1% (6/145) and showed a peak at 17-25 years (n=119 or14%). While fractures were present from 10 years in the rural males, there were no fractures in the female rural group until after 17 years of age (n=7/76) 9.2%). By contrast, urban females suffered trauma at all ages. Despite these trends, none of these differences were significant. Of the 287 individuals with fractures, 68% could be sexed, although only 34 or 11.6% came

from rural context, of which only 16 (47%) were sexed, limiting the degree of urban and rural comparison that could be carried out. The location of fractures can provide an insight into the type of activities these adolescents were performing, and how they may have differed between the sexes and contexts. When the bone affected was reported (294 fractures) and urban and rural groups compared (Tab 6), the face, wrists and hands were most frequently affected in the rural sample (both at 11.7%). The urban group suffered more fractures to their arms (i.e. humerus, radius or ulna), and this was particularly common in the males (n=23/138 or 16.7%). In the urban females, fractures were most common in their legs (i.e. femur, tibia or fibula) at 21.2% (n=10/47) and 14.9% (n=7/47) had spinal injuries. No fractures were recorded for these areas in the small sample of rural females. Only the urban group suffered fractures of the pelvis, but overall the spread of fractures throughout the skeleton was similar in both contexts. In the urban sample, a large proportion of the skull fractures seen in the 17-25 year old males (n=22 of 26 cases) were the result of blade injuries, and represent their involvement in battles.

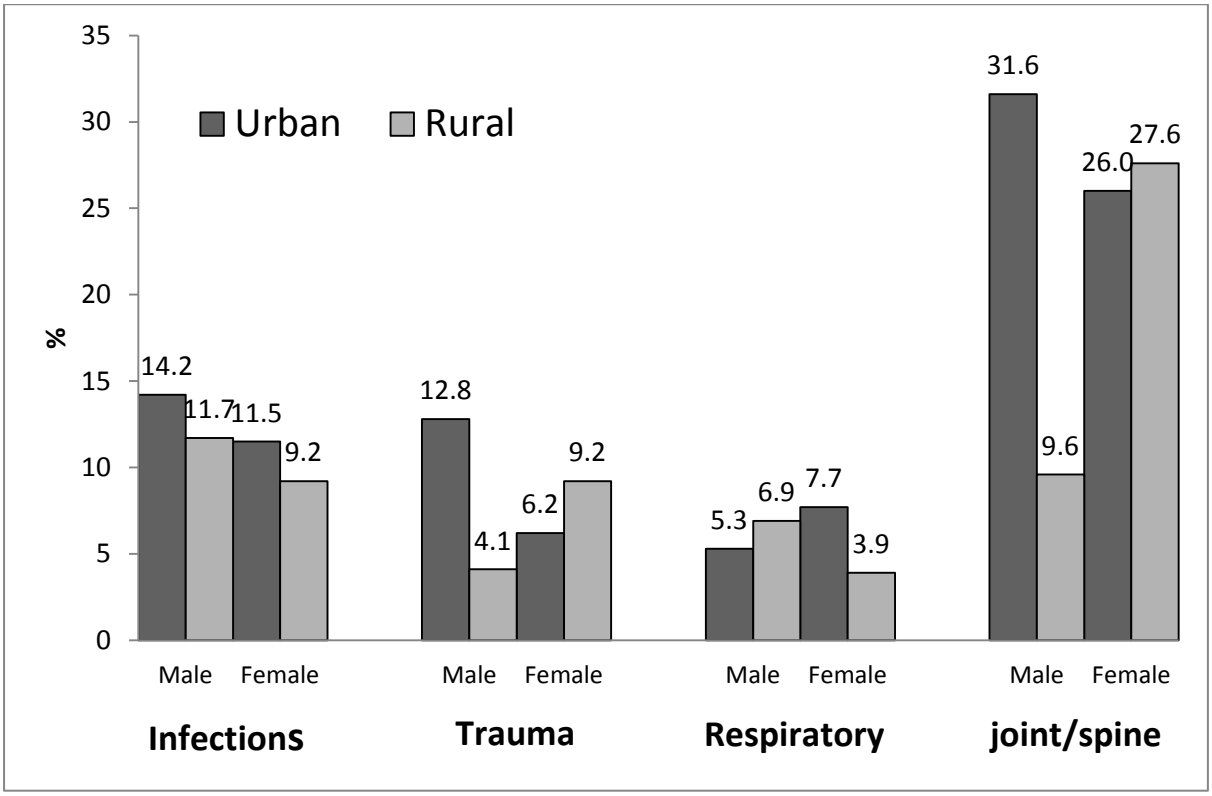


FIG 6. Crude prevalence rate (%) of occupational disease by sex in the urban and rural sites

If the fracture location patterns are compared before 18 years of age (Fig. 7), a very different picture emerges. The spread of urban trauma is much greater than in the rural adolescents with fractures to the ribs, face, hands and lower legs occurring in the 6.6-17.9 year olds, with both groups suffer trauma to the skull, upper arms and spine. When the sex distribution in the urban areas is compared (Fig. 8), the numbers of females with spinal injuries is already notable, with males showing fractures to the upper arms, femora, face and ribs. The distribution of fractures on the legs and ribs may indicate a higher number of falls for the males, or rib, nose and jaw fractures may indicate a level of interpersonal violence, through fighting. Fractures to the face and ribs appear in four urban females after the age of 18 years, with three additional women thought to have blade injuries to their

skulls and skeleton. Due to the low numbers, it was not possible to analyse the pattern of trauma between pre- and post-Black Death individuals in the rural groups, but in the urban group, fractures increased significantly after the Black Death (X^2=10.25, p=0.005, 1.d.f.), from 6.0% (134/2227) to 10.3% (41/395). This increase was most evident in the oldest age group in the post-Black Death series, where fractures rose from 3.7% (n=2/53) at 14.0-16.9 years, to 19.3% (n=33/191) at 17.0-25.0 years (Tabs A5 and A6).

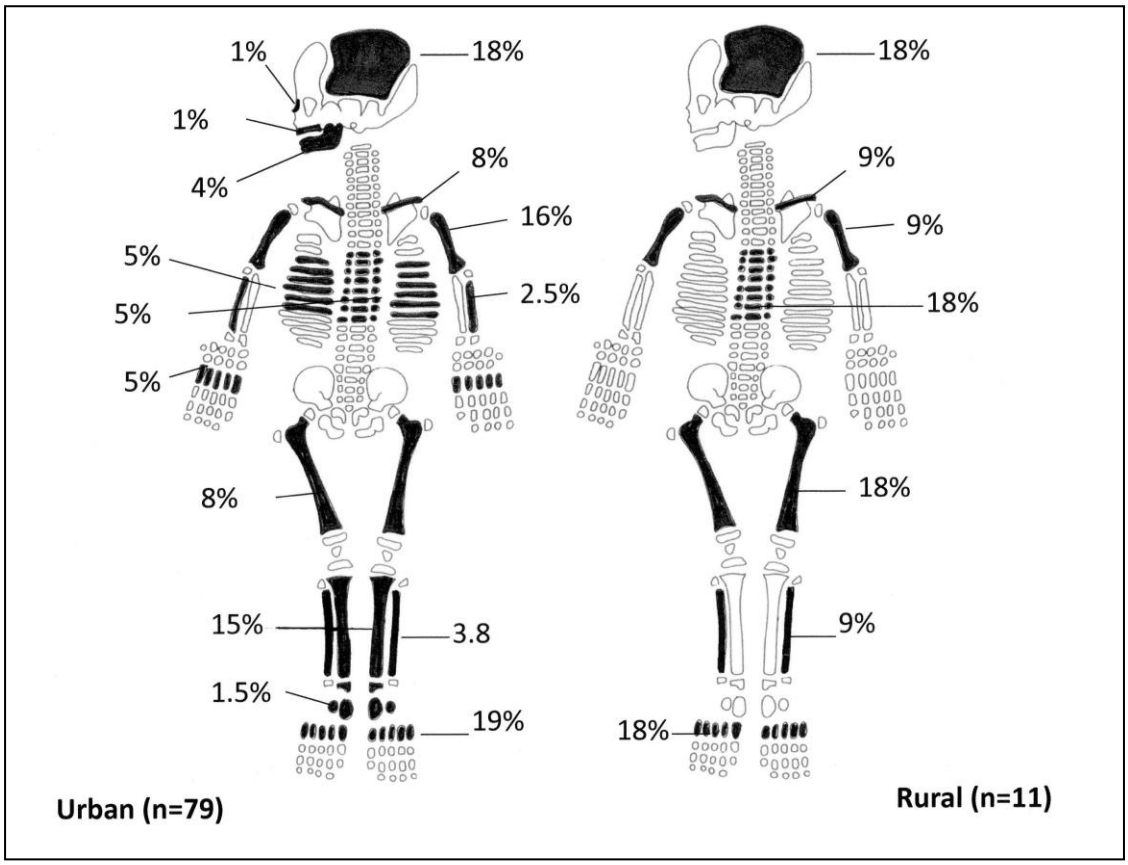


FIG 7. Distribution pattern and percentage of trauma in the urban and rural non-adults, aged 6.6-16.9 years.

RESPIRATORY DISEASES (SINUSITIS, VISCERAL RIB LESIONS, TUBERCULOSIS)

New bone formation on the internal or visceral surface of the ribs is often associated with tuberculosis (TB), but in the absence of spinal lesions was considered here to indicate general chest infections, including bronchitis and pneumonia. Tuberculosis was accepted as a diagnosis if it was based on spinal changes (Pott's disease) or septic arthritis of a large joint, a common complication in childhood TB. Once again, there were no statistically significant differences between the rates of respiratory disease in the urban and rural groups, with 4.8% (n=190/3983) and 4.3% (n=27/629) affected respectively (Tab 4). As with trauma and infections, the prevalence increased with age in the urban groups, but showed a less clear pattern in the rural sample. When broken down into age and sex, urban females suffered the most from respiratory infections at 7.7% (n=56/728), peaking after 14 years of age. Rural females only started showing signs of chronic respiratory infections after 18 years. Once again, it was the younger rural males who showed the greatest pathology, with 13% (n=3/16) of the 10.0-13.9 years olds displaying chronic respiratory infections (Tab 5). There were 50 cases of TB in the study sample (43 urban, 7 rural). When examined in more

detail, the crude prevalence rates of TB were equal between the urban and rural groups at 1%, but cases rose earlier in the urban adolescents, at 14.0-16.9 years (n=10/641 or 1.5%), compared to after 17 years in the rural groups (n=5/259 or 1.9%,). Perhaps related, is the similar increase in rib lesions in the urban sample at this younger age (2.2%). Of the 14 cases of TB reported in the females, only the urban group had the condition which first appears in the 14.0-16.9 year age group.

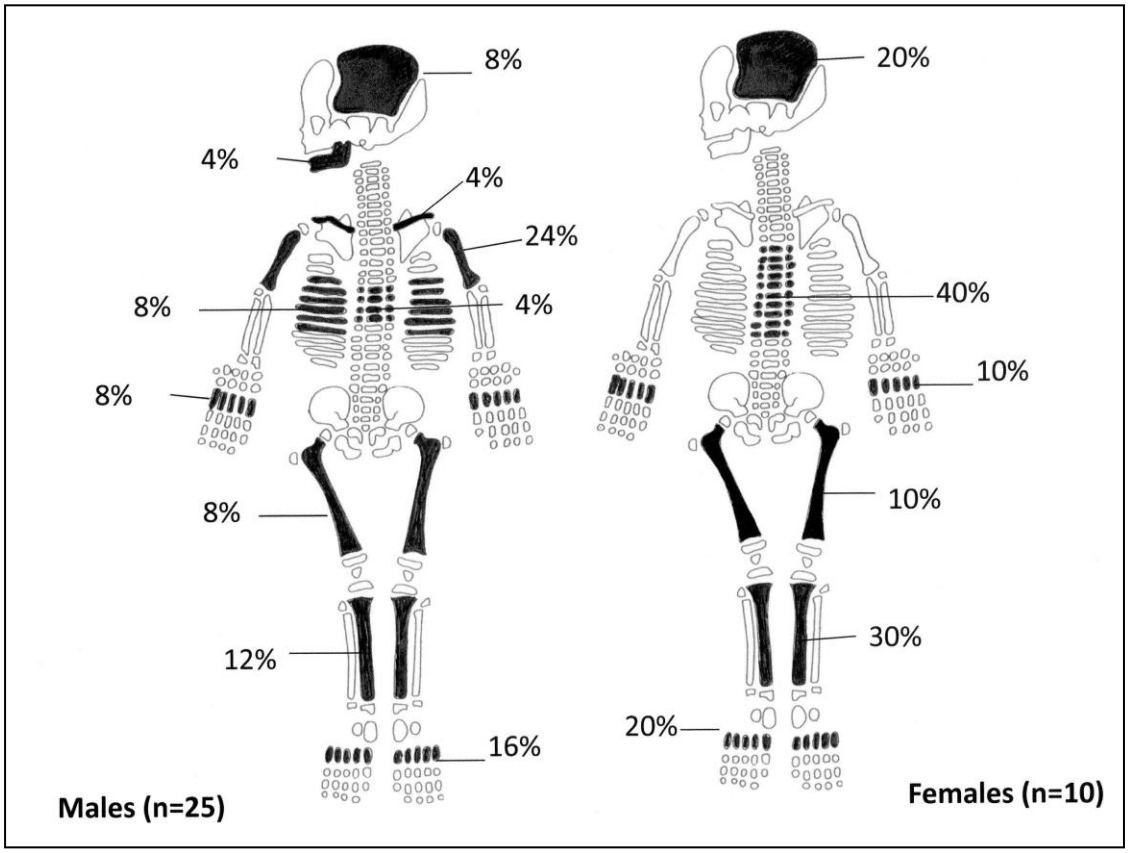


FIG 8. Distribution pattern and percentage of trauma in urban males and females, aged 6.6-16.9 years.

STRESS TO THE JOINT AND SPINE

Overall, there was significantly higher prevalence of joint and spinal disease in the urban adolescents compared to the rural (X^2=36.73, P=0.001, 1.d.f.). There were 92 cases of osteochondritis dissecans (OCD) reported in the medieval skeletons. Of these, 86 reported the location. The most common site for the OCD to occur was in the ankle (i.e. distal tibia, calcaneus, talus) with 30 cases, followed by the elbow, knee and foot (Tab 7, Fig. 9). The overall distribution of OCD was much greater in the urban group, with lesions to the shoulder, elbow and foot only occurring in these groups. In the urban groups, females suffered the highest rates of OCD in their knees (n=5/18 female OCD cases or 27.7%) whereas the males suffered most in their ankles (45.7%), this was not matched by a similar pattern in the rural groups, although the numbers with locations were low (12 cases in total). There were no reported cases of OCD before 10 years in the rural group. None of these trends were significant.

Of the 43 cases of spondylolysis, 36 (84%) occurred in the urban adolescent group, with the earliest cases evident at 6.6-9.9 years compared to 10 years in the rural sample. In both contexts the numbers rose after 17 years. Clay-shoveler's fractures, indicative of excessive bending strain on the back did not appear in either context until after 17 years of age and their prevalence was not significant in any group. In both urban and rural sites, joint disease indicative of developing arthritis was evident at much higher rates in the urban

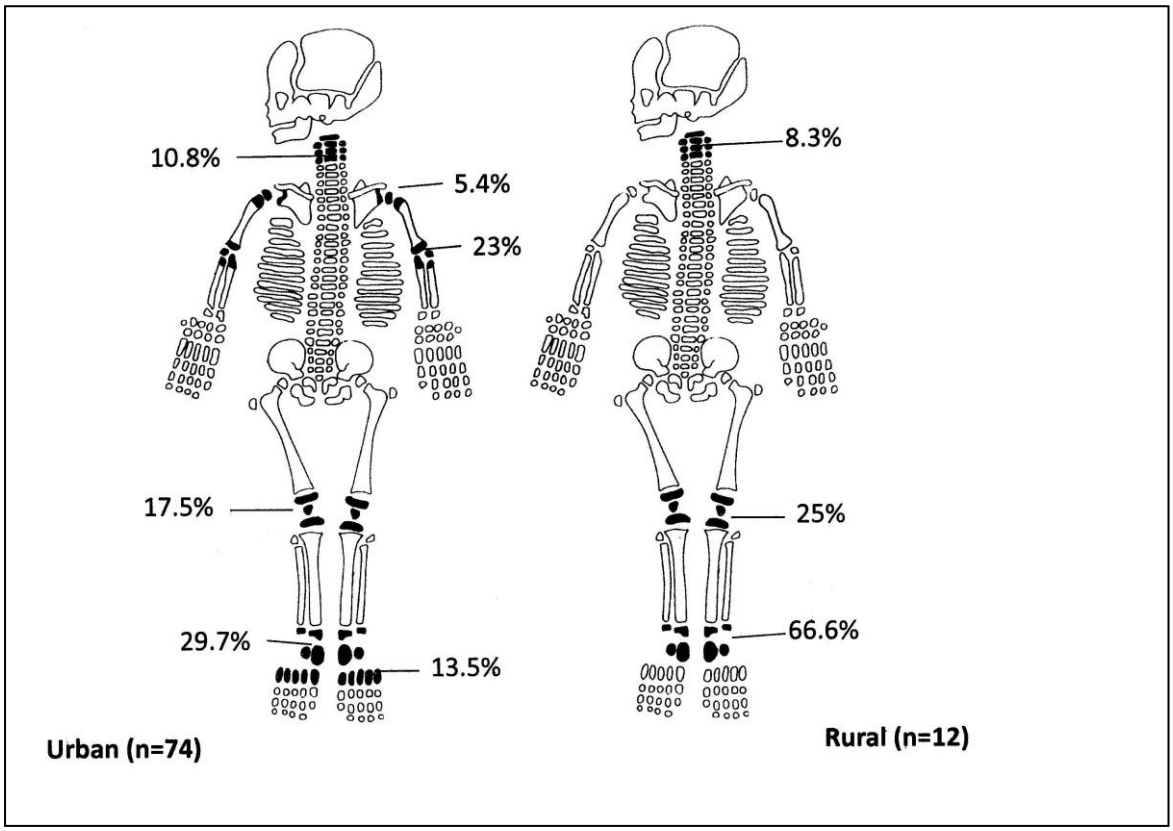


FIG 9. Percentage of OCD by given location in the urban and rural adolescents, aged 6.6-25 years.

group between 17-25 years of age (Tab 8). The earliest case of degenerative joint disease was found in a 10-13 year old male from the rural context. Schmorl's nodes were the most common lesion observed in the spines of the adolescents (Tab A2), with significantly higher levels in the urban group at 13.4% (n=425/3177) compared to the rural at 2.4% (n=15/629) (X^2=43.78, P=0.001, 1.d.f.). In the urban groups, the prevalence of these lesions increased with age, first occurring in the 10.0-13.9 year cohort, while they appeared a little later in the 14.0-16.9 year cohort for the rural groups. When broken down by sex (Tabs A3 and A4), urban males had significantly higher levels than their rural peers (n=21.5% and 3.5% respectively, X^2=27.31, P=0.001, 1.d.f.), while there were no obvious difference in the prevalence rates between the females (1.3% and 1.0% respectively). In addition, the urban males had significantly more of these depression injuries than the urban females (X^2=152.81, P=0.001, 1.d.f.), reflecting the clinical pattern where males are considered to be more susceptible to these lesions. Unlike trauma patterns, there were no discernible differences between the rate of spinal and joint lesions in the pre-and post-Black Death urban groups, except that lesions appeared in the two younger cohorts before the Black Death and were largely absent until 14.0-16.9 years after AD 1348 (Tab 9).

DISCUSSION AND CONCLUSIONS

This study represented the first large scale analysis of the health and activity of children and adolescents from medieval England (aged 6.6-25 years). The study relies on data compiled from the primary analysis of several large sites, including St Mary Spital in London and St Peter's Church, Barton-on-Humber, yielding information on nearly 1500 individuals, and complied data from published and unpublished reports and databases. The use of this secondary data provided some challenges, as many reports were published prior to recent osteological advances that allow us to recognise a greater range of pathological lesions and have refined our methods for sex and age estimation. We are always hindered when utilising skeletal data by the fact that they only represent individuals who were buried and died at each site rather than the actual number of people living in each context and within each age group. We work on the understanding that the proportion of people dying is a reflection of those living, but with migration and epidemics that struck particular portions of the population, we cannot always be sure our deductions are accurate; therefore what we can say about the demography of the sites is sometimes limited. Some pathological data was lost if its description was too ambiguous or lacked detail (i.e. location of the trauma). There was also a paucity of data for post-Black Death skeletons particularly in the rural context, frustrating attempts to explore health and activity in this important period of transition. Attempts were also made to exclude cemeteries that extended into the post-medieval period (post-AD 1550) were also excluded to ensure that the health consequences of the Industrial Revolution did not bias the results. The number of individuals representing rural cemeteries was low compared to the urban areas, reflecting the degree of excavations carried out as the result of urban developments. This discrepancy in numbers provided particular challenges when examining individual pathologies within the four main categories explored for occupational health. Although small, the pattern of fractures and joint lesions in the urban and rural groups has produced some interesting trends. In some cases, the differences in age profiles and pathology reached statistical significant differences at a 95% confidence interval and these will be discussed in more detail.

DEMOGRAPHY AND MIGRATION

Documentary evidence suggests that, before the Black Death reduced the working population in England, boys began apprenticeships between the ages of 14-16 years, with girls entering domestic service sometimes as early as 10 years. It is possible that boys who travelled to the towns under less formal circumstances were of a similar age to their wealthier counterparts. After the Black Death, parish records have suggested a slight decline in the average age of apprentices from 16 years to an average of 14 years, with more orphans in the work force as young as 10 years, and some domestic servants starting work at just 6 years old. Women became short term, small distance migrant workers, and laws were put in place to prevent anyone over the age of 12 years with agricultural experience leaving the rural environment.

One of the most striking differences in the osteological data after the Black Death is the significant drop in 6.6-9.9 year olds in the rural contexts. It is tempting to suggest that after the epidemic, younger orphaned children were making their way to the urban areas for work. There were significantly more 14.0-16.9 year olds in the urban contexts before the Black Death than in the rural sites (17.8% and 8.7% respectively). This paucity of 14.0-16.9 year olds in the rural contexts is highlighted by over double the number of 10.0-13.9 year olds (19.6%) and may reflect emigration of the older children into urban centres once they

reached 14 years. In the 14.0-16.9 year age category, there is a slight increase in the number of females in the urban context and after the Black Death the number of urban males declines. In both the pre- and post-Black Death urban samples, the proportion of 17-25 year old males was slightly higher than those from the combined 10.0 and 16.9 year age groups, however this difference increased from 5.3% to 11.5% after the Black Death (from 39.0% and 44.3%, to 33.7% and 45.2%, respectively). Changes in the demographic profile of urban males and females may reflect changes in occupation, with more young females entering domestic service, while the rising age for apprenticeships in the towns and legal obligations kept more males in the rural environment after the Black Death. But these results are not statistically significant and further research is needed to explore this pattern. In both periods, 17-25 year olds dominated the urban and rural cohorts, with significantly more 17-25 year olds in the rural contexts before the Black Death when compared to the urban groups. It's possible that some of this number represented the men and women who returned to their villages to marry and raise a family once their periods of service were complete.

Occupational health

Overall, there was a significantly higher prevalence of joint and spinal disease in the urban groups compared to their rural counterparts. The distribution of osteochondritis dissecans (OCD) was much more widespread in the urban group suggesting strain on their shoulders, elbows and feet that was absent in the rural groups, where the lesions were confined to the knees and ankles. In the urban groups, females had the highest rates of OCD in their knees (27.7%) whereas the males suffered most in their ankles (45.7%). In addition, 84% of the spondylolysis cases were urban. This fracture to the lumbar vertebrae occurs due to strain on the lower back (perhaps compromised by an underlying weakness), and there was an almost equal numbers of male and female cases. Joint disease indicative of developing arthritis was evident at much higher rates in the urban group between 17-25 years of age, although a surprising early case of degenerative joint disease was found in a 10-13 year old male from the rural context. Degenerative joint disease in adolescents is a neglected area of research in palaeopathology, and its presence is usually considered part of the ageing process. The existence of joint disease in individuals as young as 10 and 14 years due to early occupation suggests caution should be used when using this trait to suggest an older age for an individual during analysis.

Schmorl's nodes were the most common lesion observed in the spines of all adolescents, with significantly higher levels in the urban group compared to the rural. In the urban groups, the prevalence of these lesions increased with age, first occurring in the 10.0-13.9 year cohort, while they appeared a little later in the 14.0-16.9 year cohort for the rural groups. When broken down by sex, urban males had significantly higher rates of Schmorl's nodes than their rural peers. There were no discernible differences between the rate of spinal and joint lesions in the pre-and post-Black Death urban groups, except that lesions appeared in the two younger cohorts before the Black Death and were largely absent until 14.0-16.9 years after AD 1348.

Infections

Documentary sources indicate that a move to the urban environments had a detrimental effect on the health of the migrants, with smallpox being a particular concern in post-medieval populations. In the earlier periods, tuberculosis was the greatest hazard these

individuals faced. Chalke[cx] argued that TB had been on the increase before the advent of the Industrial Revolution, and that the difference in the prevalence of tuberculosis in urban and rural environments was complicated by the migratory patterns of the inhabitants. While the crude prevalence rates of TB were equal between the urban and rural groups, cases rose in the urban adolescents after 14 years compared to 18 years in the rural groups. Perhaps related, is the similar increase in rib lesions in the urban sample, particularly the females, at this younger age. This is reminiscent of documentary evidence that recalls the plight of female domestic servants who, when they became sick, would return home to the country to die,[cxi] suggesting that they contracted TB in the overcrowded urban centre. However, women leaving the countryside may have already been infected with TB, which only became manifest when they entered the stressful conditions of urban servitude.

That urban women were particularly burdened by disease is also evident in the data for treponemal diseases (Tabs A3 and A4). Nine of the 12 sexed cases of treponemal disease were urban and perhaps more surprisingly, seven of these were female (n=78%), with two aged just 14.0-16.9 years. These women were found in Gloucester and York, with three females buried in London. Treponemal disease is a term used to encompass the four different types of disease spread by *Treponema palladium*, of which yaws, a childhood condition, and venereal syphilis were known to be in Europe during the medieval period.[cxii] To show the skeletal sign of treponemal disease by 17 years suggests a much earlier exposure and makes yaws a much more palatable option. However, consideration should be given as to whether any of these young women were working as prostitutes in the port town of Gloucester and busy urban centres of York and London. Documentary evidence for York certainly suggests young women may have engaged in this form of occupation.[cxiii]

TRAUMA

When the rates of trauma were examined between the urban and rural groups, levels were very similar, following the expected clinical pattern and increasing with age. Urban females had fractures in all age groups, while in the rural context, women only suffered from skeletal trauma after 17 years of age. Rural boys were highly susceptible to fractures at 10 years, perhaps reflecting their working habits, where they were either starting work or taking on more dangerous tasks working with larger animals and farming equipment. The trauma patterns in the adolescent group show that as with joint injuries, there was a wider distribution of fractures in the urban groups. Urban females injured their spines and lower legs much more frequently than any other group, while the urban males suffered more trauma to their arms, ankles (OCD) and skulls. These patterns may be reflecting the type of work being carried out by these young individuals, with trauma pattern in the urban women perhaps reflecting the strains of domestic service on backs and knees. Males would have carried out more diverse occupations, and many worked in the building trade where heavy lifting and the dangers of falling tools and materials may explain the stress patterns we are seeing. When trauma in the urban males and females are compared before the age of 18, males suffered from fractures to the ribs and jaw, with fractured teeth and a fractured nose also occurring in two unsexed urban skeletons. It is tempting to suggest that levels of interpersonal violence caused by punches to the face and chest are indicated here, as young male apprentices were documented to become involved in riots and get into fights. However, the causes of trauma are complex and rib fractures may also result from accidental falls. Walker[cxiv] also warns that trauma seen in adolescents from urban cemeteries may have acquired their injuries in the rural environment, before they migrated.

Although numbers remain small, after 18 years facial fractures are no longer confined to the males and start to appear in the urban female group. It's possible that this may be linked to the age of marriage and the physical abuse that was documented to occur in medieval wives.[cxv] At St Mary Spital in London, Walker[cxvi] reported an increase in interpersonal violence after the 13th century as the London population rose. In the urban context, the prevalence of fractures was significantly higher after the Black Death, mirroring the patterns seen in St Mary Spital, but if population levels as a whole had been reduced, it may be that the increased rates actually reflect a change in the types of activities being carried out that held more risks of injury.

In summary, the analysis of osteological data from 151 medieval sites and 4940 individuals has shown a shift in the demographic patterns in the urban and rural groups after the Black Death, with fewer 6-10 year olds in the rural population and greater numbers of young females entering the urban contexts. The age profile for the males in the urban centres however increased, perhaps as the result of changes in the age of apprenticeship and edicts that detained 12 year olds in the rural areas to aid in agricultural production. This result is contrary to what we might expect from reading documentary sources where male apprentices were considered to be younger due to greater accessibility of work after the population decline. The data for spinal and joint disease shows that urban adolescence had higher rates of stress to their joints and injuries were more widespread throughout the skeletons. There are suggestions that domestic service caused strain on the legs and backs of the urban females, while fighting was more common in the young urban males. Overall it was the urban females that carried the burden of respiratory and infectious diseases suggesting they may have been the most vulnerable group in medieval society. This study has demonstrated the ability of osteological data to shed light on the patterns of urban and rural health, and the value of examining an often neglected section of the population, the adolescents. Medieval documentary evidence often singled them out for comment, and their physical remains are capable of providing a great deal of detailed information on their activities and life style. These data demonstrate that they were involved with occupations in both the rural and urban settlements that had a visible affect on their bodies.

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Site Type	6.6-9.9	10.0-13.9	14.0-16.9	17.0-25.0	Total
Urban (N=104)					
Male	-	98 (2.4)	186 (4.6)	913 (22.5)	**1197 (24.2)[2]**
Female	-	78 (1.9)	107 (2.6)	552 (13.6)	**737 (14.9)**
Unsexed	813 (20.0)[1]	566 (13.8)	349 (8.6)	398 (9.8)	**2126 (43.0)**
Total	813 (20.0)	742 (18.3)	642 (15.8)	1863 (45.9)	**4060 (82.1)**
Rural (N=47)					
Male	-	28 (3.2)	24 (2.7)	151(17.1)	**203 (4.1)[2]**
Female	-	20 (2.3)	12 (1.4)	133 (15.1)	**165 (3.3)**
Unsexed	163 (18.5)[1]	127 (14.4)	84 (9.5)	138 (15.7)	**511 (10.3)**
Total	163 (18.5)	175 (19.9)	120 (13.6)	422 (47.9)	**880 (17.8)**
Total overall	**976 (19.7)[2]**	**917 (18.5)**	**762 (15.4)**	**2285 (46.2)**	**4940**

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Tab 1. Total number and percent of adolescent in study sample, by site context

[1]Figures in brackets denote % of the urban or rural subsample; [2]denotes % of the total sample (n=4940)

Tab 2. Number of individuals by context

	6.6-9.9		10.0-13.9		14.0-16.9		17.0-25		Total		Total Overall
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	**Urban**	**Rural**	
Pre-Black Death AD 900-1348 (N=68)											
Male	-	-	58 (9.7)[1]	15 (13.0)	126 (21.0)	12 (10.4)	414 (69.2)	88 (76.5)	**598**	**115**	**713**
Female	-	-	55 (12.7)	8 (9.3)	61 (14.1)	8 (9.3)	317 (73.2)	70 (81.4)	**433**	**86**	**519**
Unsexed	358	84	344	67	196	20	222	85	**1120**	**256**	**1376**
Total	358 (16.6)[1]	84 (18.3)	457 (21.1)	90 (19.6)	383 (17.8)	40 (8.7)	953 (44.3)	243 (53.2)	**2151 (82.6)[2]**	**457 (17.4)[2]**	**2608**
Post-Black Death AD 1349-1550 (N=34)											
Male	-	-	12 (8.7)[1]	7 (24.1)	17 (12.4)	3 (10.3)	108 (79.0)	19 (65.5)	**137**	**29**	**166**
Female	-	-	12 (15.8)	5 (22.7)	15 (19.7)	3 (13.6)	49 (64.4)	14 (63.6)	**76**	**22**	**98**
Unsexed	88	7	58	13	27	10	32	17	**205**	**47**	**252**
Total	88 (21.0)[1]	7 (7.1)	82 (19.6)	25 (25.5)	59 (14.1)	16 (16.3)	189 (45.2)	50 (51.0)	**418 (81.0)[2]**	**98 (18.9)[2]**	**516**

[1]percent in either the urban or rural site; [2] percent urban or rural from each period

Tab 3. Number of aged and sexed individuals with pathology data available

Age category	Total urban	Urban males	Urban females	Total rural	Rural males	Rural females	Total Overall
6.6-9.9	806	-	-	142	-	-	**948**
10.0-13.9	732	95	77	133	16	9	**865**
14.0-16.9	641	184	106	95	24	11	**736**
17.0-25.0	1804	846	545	259	105	76	**2063**
Total	**3983**	1125	728	**629**	145	96	**4612**

Tab 4. Percentage prevalence of occupational pathology in urban vs. rural age groups (years)

Category	6.6-9.9		10.0-13.9		14.0-16.9		17.0-25.0		Total Urban	Total Rural
	Urban (%806)[1]	Rural (%142)	Urban (%732)	Rural (%133)	Urban (%641)	Rural (%95)	Urban (%1804)	Rural (%259)	Urban (%3983)	Rural (%629)
Infection	57 (7.0)	12 (8.4)	63 (8.6)	15 (11.2)	76 (11.8)	7 (7.4)	258 (14.3)	22 (8.5)	454 (11.4)	56 (8.9)
Trauma	20 (2.5)	3 (2.1)	29 (3.9)	3 (2.2)	39 (6.0)	5 (5.2)	170 (9.4)	18 (6.9)	258 (6.4)	29 (4.6)
Respiratory Infection	19 (2.3)	7 (4.9)	19 (2.6)	5 (3.7)	32 (5.0)	4 (4.2)	120 (6.6)	11 (4.2)	190 (4.8)	27 (4.3)
Spine and Joint	9 (1.1)	0 (0.0)	19 (2.6)	5 (3.7)	79 (12.3)	6 (6.3)	556 (30.8)	35 (13.5)	663 (16.6)[#]	46 (7.3)

[1]number represents total individuals examined for pathology; [#]significant at 95% confidence internal

Tab 5. Percentage prevalence of occupational pathology in urban and rural males and females, by age

Category	10.0-13.9		14.0-16.9		17.0-25.0		Total Urban	Total Rural
Males								
	Urban (%95)[1]	Rural (%16)	Urban (%184)	Rural (%24)	Urban (%846)	Rural (%105)	Urban (%1125)	Rural (%145)
Infection	9 (9.4)	2 (12.5)	22 (11.9)	3 (12.5)	129 (15.2)	12 (11.4)	160 (14.2)	17 (11.7)
Trauma	7 (7.3)	1 (6.2)	18 (9.8)	1 (4.2)	119 (14.0)	4 (3.8)	144 (12.8)	6 (4.1)
Respiratory Infection	2 (2.1)	3 (13.0)	9 (4.9)	0	49 (5.8)	7 (6.6)	60 (5.3)	10 (6.9)
Spine and Joint Stress	5 (5.2)	2 (12.5)	34 (18.4)	1 (4.2)	317 (37.4)	11 (10.4)	356 (31.6)	14 (9.6)
Females								
	Urban (%77)	Rural (%9)	Urban (%106)	Rural (%11)	Urban (%545)	Rural (%76)	Urban (%728)	Rural (%76)
Infection	3 (3.9)	0	14 (13.2)	2 (18.1)	67 (12.2)	5 (6.5)	84 (11.5)	7 (9.2)
Trauma	4 (5.1)	0	5 (4.7)	0	36 (6.6)	7 (9.2)	45 (6.2)	7 (9.2)
Respiratory Infection	3 (3.9)	0	9 (8.2)	0	44 (8.0)	3 (3.9)	56 (7.7)	3 (3.9)
Spine and Joint Stress	1 (1.3)	1 (11.0)	17 (16.0)	1 (9.0)	172 (31.5)	19 (25.0)	190 (26.0)	21 (27.6)

[1]number represents total examined for pathology

Tab 6. Location of fractures by site type and sex

Location	Urban Male (%)[1]	Urban Female (%)[2]	Urban Unsexed	Rural Male (%)[1]	Rural Female (%)[2]	Rural Unsexed	**Total Urban (%urban)**	**Total Rural (%rural)**	**Total Overall**
Skull	32 (23.1)	8 (17.0)	15	1 (12.5)	2 (25.0)	4	**55 (21.2)**	**7 (20.5)**	**62**
Face	5 (4.3)	0 (0)	2	2 (25.0)	2 (25.0)	0	**7 (2.7)**	**4 (11.7)**	**11**
Shoulders	13 (9.4)	5 (10.6)	4	0	1 (12.5)	1	**22 (8.5)**	**2 (5.9)**	**24**
Arms	23 (16.7)	4 (8.5)	11	1 (12.5)	1 (12.5)	1	**38 (14.7)**	**3 (8.8)**	**41**
Hands/wrists	6 (4.3)	3 (6.4)	2	2 (25.0)	1 (12.5)	1	**11 (4.2)**	**4 (11.7)**	**15**
Ribs	10 (7.2)	4 (8.5)	8	0	0	2	**22 (8.5)**	**2 (5.9)**	**24**
Spine	11 (7.9)	7 (14.9)	4	0	0	2	**22 (8.5)**	**2 (5.9)**	**24**
Pelvis	3 (2.1)	1 (2.1)	1	0	0	0	**5 (1.9)**	**0**	**5**
Legs	18 (13.0)	10 (21.2)	16	2 (25.0)	0	3	**44 (16.9)**	**5 (14.7)**	**49**
Feet/ankles	17 (12.3)	5 (10.6)	12	0	1 (12.5)	4	**34 (13.1)**	**5 (14.7)**	**39**
Total (%)[3]	**138 (47.0)**	**47 (16.0)**	**75**	**8 (2.7)**	**8 (2.7)**	**18**	**260 (88.3)**	**34 (11.6)**	**294**

(%)[1] = percent of total male fractures; (%)[2]=total of female fractures; (%)[3]=percent total fractures in sample

Tab 7. Location of osteochondritis dissecans by site type and sex

Location	Urban Male (%)[1]	Urban Female (%)[2]	Unsexed	**Total Urban (%urban)**	Rural Male (%)[1]	Rural Female (%)[2]	Unsexed	**Total Rural (%rural)**	**Total Overall**
Neck	4 (11.4)	1 (5.5)	3	**8 (10.8)**	0	0	1	**1 (8.3)**	**9**
Shoulder	2 (5.7)	0	2	**4 (5.4)**	0	0	0	**0**	**4**
Elbow	6 (17.1)	4 (22.2)	7	**17 (23.0)**	0	0	0	**0**	**17**
Knee	4 (11.4)	5 (27.7)	4	**13 (17.5)**	1 (50.0)	1 (25.0)	1	**3 (25.0)**	**16**
Ankle	16 (45.7)	4 (22.2)	2	**22 (29.7)**	1 (50.0)	3 (75.0)	4	**8 (66.6)**	**30**
Foot	3 (10.5)	4 (22.2)	3	**10 (13.5)**	0	0	0	**0**	**10**
Total	**35 (40.6)**	**18 (21.0)**	**21**	**74 (86.0)**	**2 (2.3)**	**4 (4.6)**	**6**	**12 (13.9)**	**86**

(%)[1] = percent of total male OCD; (%)[2]=total of female OCD; (%)[3]=percent total OCD in sample

Tab 8. Percentage prevalence of occupational pathology pre-AD 1348 (urban vs. rural)

Category	6.6-9.9		10.0-13.0		14.0-16.9		17.0-25.0		Total Overall	
	Urban (%356)[1]	Rural (%82)	Urban (%455)	Rural (%88)	Urban (%407)	Rural (%39)	Urban (%1009)	Rural (%243)	Urban (%2227)	Rural (%452)
Infection	18 (5.0)	10 (12.1)	43 (9.4)	6 (6.8)	42 (10.3)	6 (15.3)	154 (15.2)	10 (4.1)	239 (10.7)	32 (7.0)
Trauma	5 (1.4)	2 (2.4)	15 (9.6)	3 (3.4)	25 (6.1)	4 (10.2)	75 (7.4)	10 (4.1)	120 (5.4)	19 (4.2)
Respiratory	5 (1.4)	7 (8.5)	9 (1.9)	4 (4.5)	26 (6.4)	0	76 (7.5)	6 (2.5)	116 (5.2)	17 (3.8)
Spine and Joint	5 (1.4)	0	15 (9.6)	4 (4.5)	82 (20.1)	1 (2.5)	394 (39.0)	18 (7.4)	496 (22.2)	23 (5.1)

[1]number represents total number of individuals

Tab 9. Percentage prevalence of urban occupational pathology pre- and post-AD 1348

Category	6.6-9.9		10.0-13.0		14.0-16.9		17.0-25.0		Total Urban	
	Pre (%356)[1]	Post (%4)	Pre (%455)	Post (%69)	Pre (%407)	Post (%53)	Pre (%1009)	Post (%191)	Pre (%2227)	Post (%317)
Infection	18 (5.0)	0	43 (9.4)	2 (2.9)	42 (10.3)	7 (13.2)	154 (15.2)	20 (10.4)	239 (10.7)	29 (9.1)
Trauma	5 (1.4)	0	15 (9.6)	2 (2.9)	25 (6.1)	3 (5.7)	75 (7.4)	37 (19.3)	120 (5.4)	42 (13.2)[#]
Respiratory	5 (1.4)	0	9 (1.9)	2 (2.9)	26 (6.4)	1 (2.0)	76 (7.5)	10 (5.2)	116 (5.2)	13 (4.1)
Spine and Joint	5 (1.4)	0	15 (9.6)	1 (1.4)	82 (20.1)	9 (16.9)	394 (39.0)	59 (30.8)	496 (22.2)	69 (21.7)

[1]=number represents total number of individuals with pathology status available; [#]significant at 95% confidence interval

SUPPLEMENTARY TABLES

Tab A1a: List and context of sites yielding individuals buried before the Black Death (pre-1348)

Site Name	Location	Date	Type	Source	N.
All Saints, Barton Bendish	Norfolk	11-12th century	Rural, High Status	Stroud 1984	8
Barnstable Castle	Devon	AD 700-1100	Urban, Castle	Bayley 1976	28
Bishopstone	Sussex	AD 855-1020	Rural, Lay Cemetery	Schoss and Lewis 2011	9
Caister-on-Sea	Norfolk	8-11th century	Rural, Lay Cemetery	Anderson 1990	34
Cannington	Somerset	7-11th century	Rural, Lay Cemetery	Brothwell and Powers 2000	2
Chevington Chapel	Northumbria	12th century	Rural, Lay Cemetery	Boylston et al. 1998	13
Chimney, Bampton	Oxford	AD 950-1060	Rural, Lay Cemetery	Crawford et al. 1989	9
Cressing Temple Preceptory	Essex	AD 1136-1310	Rural, Templar	Gilchrist and Slone (ADS)	7
Didcot	Oxfordshire	AD 900-1066	Rural, Lay Cemetery	Boyle et al. 1995	5
East Smithfield	London	AD 1348-1350	Urban, Black Death	Museum of London WORD	180
Eynsham Abbey	Oxfordshire	12-13th century	Urban, Monastery	Boyle 2003	3
Farmer's Avenue	Norwich	10-14th century	Urban, Lay Cemetery	Anderson 2009	22
Faringdon Road Abingdon	Oxfordshire	AD 1100-1390	Urban, Lay Cemetery	Harman and Wilson 1981	4
Fishergate House	York	AD 1020-1220	Urban, Lay Cemetery	*Primary data*	5
Gorefields	Buckinghamshire	AD 1100-1400	Rural, Nunnery	Maynard and Ivens 2002	1
Greyfriars	Norwich	12th century	Urban, Friary	Boghi 2007a	1
Guildhall Yard	London	AD 1050-1350	Urban, Lay Cemetery	Museum of London WORD	23
Hereford Castle Green	Hereford	AD 900-1175	Urban, Lay Cemetery	Shoesmith 1980	25
Jarrow Monastery	Tyne and Wear	7-11th century	Urban, Lay Cemetery	Anderson et al. 2006	44
Jewbury	York	AD 1177-1290	Urban, Jewish Burial	Brothwell and Browne 1994	97
Jewish Cemetery	Winchester	AD 1177-1290	Urban, Jewish Burial	Gilchrist and Slone (ADS)	20
Kirkham Priory	Yorkshire	AD 996-1268	Rural, Priory	Bayley 1979a, Holst 2006	2
Llandough Monastery	Glamorgan	4-12th century	Urban, Lay Cemetery	Loe and Robson-Brown 2005	161
Llanthony Secunda Priory	Gloucester	12-13th century	Rural, Priory	Clough 2006a	3
Merton Priory	London	AD 1117-1390	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	33
Mill Lane, Thetford	Norfolk	10-11th century	Urban, Lay Cemetery	Anderson 2004	3
North East Bailey, Norwich Castle	Norwich	10-11th century	Urban, Lay Cemetery	Stirland 1985	26
North Elham Park	Norwich	9-11th century	Urban, Lay Cemetery	Wells 1980	30

Portchester Castle	Hampshire	10-11th century	Rural, High status	Hooper 1975	10
Raunds Furnells	Northamptonshire	10-11th century	Rural, Lay Cemetery	Powell 1996	28
Riccall Landing	Yorkshire	AD 680-1150	Rural, Lay Cemetery	Buckberry and Storm 2008	7
Romsey Abbey	Winchester	13th century	Urban, Abbey	Osborne 1996	3
School Street	Ipswich	AD 10-11th century	Rural, Lay Cemetery	Mays 1989a	28
Shakespeare Dock	Doncaster	10-11th century	Urban, Hospital	Bayley 1975	3
Sherbourne Abbey and School	Dorset	AD 600-1000	Rural, Abbey	Rogers 2005	1
Sherbourne Old Castle	Dorset	AD 600-1240	Rural, Lay Cemetery	Harrison and Bayley 1978	5
South Acre	Norfolk	AD 1150-1350	Rural, Execution cemetery	Mckinley 1996	58
Spital Square	London	AD 1197-1320	Urban, Lay Cemetery	Museum of London (WORD)	29
St Andrew Fishergate	York	12-14th century	Urban, Lay Cemetery	Stroud 1993a, Duncan 2000	43
St George's Chapel, Oxford Castle	Oxford	AD 900-1200	Urban, Castle	Loe 2005	2
St Giles, Brompton Bridge	Yorkshire	AD 1250-1400	Rural, Hospital	Chundun and Roberts 1995	3
St James' Priory	Bristol	AD 1120-1170	Urban, Lay Cemetery	Loe and Lamb 2006	2
St John's Abbey	Colchester	AD 1095-1200	Urban, Abbey	Crummy et al. 1993	13
St Lawrence Jewry	London	AD 1050-1150	Urban, Jewish Burial	Gilchrist and Slone (ADS)	27
St Mark's Church	Lincoln	10-13th century	Urban, Lay cemetery	Dawes 1986	17
St Mary's Church, Rivenhall	Essex	10-14th century	Rural, Lay Cemetery	O'Connor 1993	25
St Mary Graces	London	AD 1348-1350	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	42
St Mary Magdalene, Partney	Lincolnshire	AD 1160-1260	Rural, Hospital	Anderson 2010	1
St Mary Merton	Surrey	AD 1117-1390	Rural, Priory	Gilchrist and Slone (ADS)	35
St Mary Nunnaminster	Winchester	AD 1120-1350	Urban, Nunnery	Gilchrist and Slone (ADS)	4
St Mary Spital	London	AD 1120-1400	Urban, Lay Cemetery	*Primary data*	753
St Mary Stratford, Langthorne	Essex	AD 1135-1400	Rural, Lay Cemetery	Gilchrist and Slone (ADS)	121
St Mary's Priory, Guisborough	Yorkshire	AD 1120-1200	Urban, Priory	Heslop 1995	9
St Michael's, Thetford	Norfolk	11-12th century	Urban, Lay Cemetery	Stroud 1993b	16
St Nicolas Shambles	London	11-12th century	Urban, Lay Cemetery	White 1988	49
St Oswald's Priory	Gloucester	AD 900-1230	Urban, Lay Cemetery	*Primary data*	38
St Pancras, Lewes	Sussex	AD 1150-1225	Urban, Priory	Lyne 1997	3
St Peter's Church, Barton-on-Humber	Lincolnshire	AD 950-1300	Urban, Lay Cemetery	*Primary data*	120
St Peter's Priory, Dunstable	Bedfordshire	AD 1130-1300	Urban, Priory	Gilchrist and Slone (ADS)	5

St Peter-le-Bailey, Bonn Square	Oxford	11th century	Urban, Lay Cemetery	Webb and Loe 2009	23
St Peter's Street	Ipswich	9-10th century	Urban, Lay Cemetery	Mays 1989b	3
St Saviour Bermondsey	London	AD 1050-1330	Urban, Lay Cemetery	Museum of London WORD	20
St Stephen's Church	York	AD 1000-1303	Urban, Lay Cemetery	Tucker 2005	20
Sts James and Mary Magdalene	Sussex	AD 1100-1300	Urban, Leprosarium	*Primary data*	28
Walkington Wold	Yorkshire	AD 640-1050	Rural, Execution Cemetery	Buckberry and Hadley 2007	8
Wearmouth Monastery	Tyne and Wear	7-11th century	Urban, Lay Cemetery	Anderson et al. 2006	65
Wharram Percy	Yorkshire	AD 950-1348	Rural, Lay Cemetery	Mays 2007	97
York Minster	York	9-12th century	Urban, Royal	Philips and Heywood 1995	46

Tab A1b: List and context of sites yielding individuals buried before the Black Death (post-1348)

Site Name	**Location**	**Date**	**Type**	**Source**	**N.**
Austin Friars	Leicester	AD 1380-1538	Urban, Friary	Stirland 1981	2
Carmelite Friary, Linlithgow	West	AD 1400-1560	Urban, lay Cemetery	Lindsay 1989	50
Eynsham Abbey	Oxfordshire	14-15th century	Urban, Monastery	Boyle 2003	1
Fishergate House	York	AD 1420-1530	Urban, Lay Cemetery	*Primary data*	11
Huntingdon Castle Mound	Cambridges	8-17th century	Rural, Lay Cemetery	Vincent and Mays 2009	14
Litten Cemetery	Berkshire	13-16th century	Rural, Hospital	Clough and Hardy 2006	17
Merton Priory	London	AD 1390-1538	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	4
Motte Ditch, Oxford Castle	Oxford	15-17th century	Urban, Execution	Loe 2005	6
St Andrew's Fishergate	York	14-16th century	Urban, Lay Cemetery	Stroud 1993a, Duncan	55
St Andrew's, Rochester	Kent	AD 1350-1500	Urban, Priory/Cathedral	Gilchrist and Slone (ADS)	2
St Anne's Charterhouse	Coventry	AD 1450-1539	Urban, Priory	Gilchrist and Slone (ADS)	7
St Augustine's Abbey, Maidstone	Kent	AD 1350-1538	Urban, Lay Cemetery	Powell 1979, Bayley 1988	28
St Augustine's Friary	Hull	AD 1340-1538	Urban, Lay Cemetery	Holst et al. 2001	9
St Bartholomew's Hospital	Bristol	AD 1340-1532	Urban, Hospital	Stroud 1998	5
St Faith's Lane	Norwich	AD 1400-1538	Urban, Lay Cemetery	Anderson 2010	10
St John of Jerusalem, Clerkenwell	London	AD 1480-1540	Urban. Hospital	Slone and Malcom 2004	6
St Mark's Church	Lincoln	14-16th century	Urban, Lay cemetery	Dawes 1986	6
St Martin's Field, New Romney	Kent	AD 1396-1495	Urban, Hospital	Clough 2006a	8

St Mary's Church, Rivenhall	Essex	14-17th century	Rural, Lay Cemetery	O'Connor 1993	5
St Mary Graces	London	AD 1350-1539	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	48
St Mary Merton	Surrey	AD 1350-1538	Rural, Priory	Gilchrist and Slone (ADS)	9
St Mary Nunnaminster	Winchester	AD 1400-1539	Urban, Nunnery	Gilchrist and Slone (ADS)	4
St Mary Sandwell	Staffordshir	AD 1450-1525	Rural, Priory	Flinn 1991	6
St Mary Spital	London	AD 1400-1539	Urban, Lay Cemetery	*Primary data*	142
St Mary Stratford, Langthorne	Essex	AD 1350-1538	Rural, Lay Cemetery	Gilchrist and Slone (ADS)	11
St Michael, Bowthorpe	Norfolk	14th century	Rural, Lay Cemetery	Stirland 2001	2
St Nicolas, Lewes	Sussex	AD 1350-1560	Urban, Hospital	Browne 1998	1
St Pancras, Lewes	Sussex	AD 1350-1538	Urban, Priory	Lyne 1997	2
St Peter and Grimbald	Winchester	AD 1400-1538	Urban, Abbey	Gilchrist and Slone (ADS)	7
St Peter's Church, Barton-on-	Lincolnshire	AD 1300-1500	Urban, Lay Cemetery	*Primary data*	11
St Saviour Bermondsey	London	AD 1330-1430	Urban, Lay Cemetery	Museum of London	1
Towton	Yorkshire	AD 1461	Urban, War grave	Fiorato et al. 2000	13
Westminster Abbey	London	15th century	Urban, Royal	Hammond and White	3
Wharram Percy	Yorkshire	AD 1348-1540	Rural, Lay Cemetery	Mays 2007	10

Tab A1c: List and context of sites yielding individuals spanning the medieval period Table A1b

Site Name		**Date**	**Type**	**Source**	
Abingdon Abbey	Oxfordshire	AD 1239-1539	Urban, Abbey	Duncan 2000	8
Austin Friars	Leicester	AD 1248-1538	Urban, Friary	Stirland 1981	19
Back Gladstone Street, Hartlepool	Cleveland	Medieval	Rural, lay Cemetery	Proudfoot and Wells 1975	8
Blackfriars, School Street	Ipswich	AD 1253-1538	Rural, Lay Cemetery	Mays 1991a	48
Blackfriars Street	Carlisle	AD 1240-1538	Urban, Friary	Henderson 1990	48
Blackfriars	Gloucester	AD 1246-1539	Urban, Hospital	Roberts 1994	21
Blackfriars	Oxford	AD 1236-1538	Urban, Lay Cemetery	Lambrick and Woods 1976	27
Bordesley Abbey	Hereford	AD 1138-1538	Urban, Abbey	Everton et al. 1976	7
Brighton Hill South (Hatch Warren),	Sussex	AD 1067-1539	Rural, Lay Cemetery	Waldron 1987	2
Carter Lane	London	AD 1200-1538	Urban, Friary	Museum of London	12
Castle Mound	Norwich	AD 1067-1789	Execution Cemetery	Wells 1982	1

Chelmsford Blackfriars	Essex	AD 1138-1538	Urban, Lay Cemetery	Bayley 1975a	34
Cressing Temple Preceptory	Essex	AD 1310-1540	Rural, Templar Site	Gilchrist and Slone (ADS)	3
Crutched Friary, Colchester	Essex	AD 1200-1538	Urban, Lay Cemetery	Boghi 2007b	16
Denny Abbey, Waterbeach	Cambridgeshire	AD 1200-1538	Rural, Abbey	Powers and Keepax 1974	2
Dominican Friary	Oxford	AD 1236-1538	Urban, Friary	Gilchrist and Slone (ADS)	3
Dominican Friary	Perth	AD1231-1559	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	22
Faversham	Kent	AD 1147-1500	Rural, Royal Site	Wells 1968	2
Fishergate House	York	AD 1020-1530	Urban, Lay Cemetery	*Primary data*	28
Fontevraultine Priory, Grove	Bedfordshire	AD 1200-1450	Rural, Priory	Gilchrist and Slone (ADS)	6
Franciscan Friary, Hartlepool	Cleveland	AD 1290-1538	Urban, Lay Cemetery	Birkett 1986	27
Franciscan Friary, Lewes	Sussex	AD 1240-1538	Urban, Friary	Browne 1996	21
Franciscan Friary, Northampton	Northamptonshi	AD1067-1539	Urban, Friary	Gilchrist and Slone (ADS)	2
Grantham, London Road	Lincolnshire	AD 1164-1500	Urban,	Boulter 1992	9
Greyfriars	Carmarthen	AD 1240-1550	Urban, Friary	Gilchrist and Slone (ADS)	30
Greyfriars	Gloucester	AD 1231-1538	Urban, Friary	Ferris 2001	3
Greyfriars	Northampton	AD 1067-1539	Urban, Friary	Griffiths 1978	2
Greyfriars Court	Chester	AD 1236-1536	Urban, Lay Cemetery	West 1990	12
Guildford Blackfriars	Sussex	AD 1275-1538	Urban, Lay Cemetery	Henderson 1984	17
Hulton Abbey	Staffordshire	AD 1219-1542	Rural, Lay Cemetery	*Primary data*	17
Jarrow Monastery	Tyne and Wear	11-16th century	Urban, Lay Cemetery	Anderson et al. 2006	47
Lincoln Sites (upper city)	Lincolnshire	AD 900-1700	Urban, Lay Cemetery	Boylston and Roberts	14
Malmesbury Abbey	Wiltshire	AD 1067-1539	Urban, Lay Cemetery	Henderson and Ives 2011	12
Merton Priory	London	AD 1117-1538	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	18
Poulton Chapel, Chester	Cheshire	AD 1153-1700	Rural, High Status	Carpenter and Crane 2010	73
Redcastle Furze, Thetford	Norfolk	Medieval	Urban, lay Cemetery	Stroud 1988	1
Spital Square	London	AD 1200-1500	Urban, Lay Cemetery	Museum of London	22
St Andrew's, Rochester	Kent	1067-1700	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	4
St Augustine's Friary	Hull	AD 1320-1538	Urban, Lay Cemetery	Holst et al. 2001	32
St Benedict's Church, Norwich	Norfolk	Medieval	Urban, lay Cemetery	Wells 1982	3
St Benet Sherehog	London	AD 1250-1500	Urban, Lay Cemetery	Museum of London	6
St Clement	York	AD 1130-1536	Urban, Lay Cemetery	Gilchrist and Slone (ADS)	22

St Faith's Lane	Norwich	AD 1067-1538	Urban, Lay Cemetery	Anderson 2010	73
St Gregory's Priory, Canterbury	Kent	AD 1084-1537	Urban, Lay Cemetery	Anderson 2001	25
St Guthlac's Priory	Hereford	AD 1143-1538	Urban, Priory	Shoesmith 1984	4
St Helen-on-the-Walls	York	AD 1100-1550	Urban, Lay Cemetery	*Primary data*	176
St James' Priory	Bristol	AD 1129-1450	Urban, lay Cemetery	Loe and Lamb 2006	37
St John de Berstrete, Timberhill	Norwich	AD 1157-1550	Urban,	Anderson 2009	66
St Leonard's, Newark	Nottinghamshir	AD 1133-1642	Urban, Hospital	Gilchrist and Slone (ADS)	21
St Margaret's, High Wycombe	Buckinghamshir	AD 1200-1538	Urban,	Farley and Manchester	3
St Margaret's, Huntington	Cambridge	AD 1150-1461	Rural,	Mitchell 1993	13
St Mark's Church	Lincoln	13-16th century	Urban, Lay Cemetery	Dawes 1986	6
St Martin's Church, Wallingford	Oxfordshire	AD 1172-1700	Urban, Lay Cemetery	Boston 2006	15
St Martin's Railway	Lincolnshire	AD 1269-1538	Urban, Friary	Isaac and Roberts 1997	8
St Mary Elstow	Bedfordshire	AD 1178-1539	Rural, Nunnery	Gilchrist and Slone (ADS)	24
St Mary Magdalene, Bawtry	Yorkshire	AD 1200-1680	Rural, Hospital	Hadley and McKintyre	5
St Mary Magdalene, Bidlington	Sussex	AD 1271-1553	Rural,	Radcliffe-Densham 1964	4
St Mary Magdalene, Partney	Lincolnshire	AD 1115-1550	Rural, Hospital	Anderson 2010	6
St Mary Magdalene, Winchester	Hampshire	AD 1148-1600	Urban,	Tucker pers. comm.	21
St Mary Merton	Surrey	AD 1117-1538	Rural, Priory	Gilchrist and Slone (ADS)	15
St Mary Norton, Runcorn	Cheshire	AD 1134-1536	Rural, Lay Cemetery	Gilchrist and Slone (ADS)	13
St Mary of Ospringe (Maison Dieu)	Kent	AD 1232-1571	Rural, Hospital	Bayley 1979b	4
St Mary's Abbey	Worcester	AD 1100-1500	Urban Priory/Cathedral	Gilchrist and Slone (ADS)	65
St Mary's Church, Stafford	Staffordshire	AD 913-1700	Urban, Lay Cemetery	Carver and Cane 2010	9
St Mary's Cirencester	Gloucestershire	AD 1200-1530	Urban, Abbey	Gilchrist and Slone (ADS)	2
St Mary's, Rivenhall	Essex	10-16th century	Rural, Lay Cemetery	O'Connor 1993	2
St Mary Sandwell	Staffordshire	AD 1150-1525	Rural, Priory	Flinn 1991	4
St Mary Spital	London	AD 1067-1539	Urban, Lay Cemetery	*Primary data*	134
St Michael's Church, Bowthorpe	Norwich	AD 1300-1500	Rural, Lay Cemetery	Stirland 2001	2
St Michael-in-Wigford, Pennell Street	Lincoln	10-16th century	Urban, Lay Cemetery	Boghi and Boylston 1997	16
St Neots Priory	Cambridge	AD 1113-1539	Urban, Priory	Gilchrist and Slone (ADS)	10
St Nicholas Church, Chadlington	Oxfordshire	11-16th century	Rural, Lay Cemetery	Webb and Loe 2008	3
St Nicolas, Lewes	Sussex	AD 1150-1560	Urban, Hospital	Browne 1998	37

St Oswald's Priory	Gloucester	AD 1230-1540	Urban, Lay Cemetery	*Primary data*	9
St Peter's Church, Barton-on-Humber	Lincolnshire	AD 1300-1700	Urban, Lay Cemetery	*Primary data*	166
St Saviour Bermondsey	London	AD 1050-1330	Urban, Lay Cemetery	Museum of London WORD	17
Stonar, Sandwich	Kent	AD 1067-1700	Urban, Lay Cemetery	Eley and Bayley 1975	26
Sts James and Mary Magdalene	Sussex	AD 1100-1530	Urban, Leprosarium	*Primary data*	55
Sts John and Teulyddog	Carmarthen	AD 1125-1538	Urban, Priory	Jones 1985	16
Sts Mary and Thomas	Ilford	AD 1140-1538	Urban,	Ingram 2005	1
Sts Peter and Paul, Taunton	Somerset	AD 1138-1539	Rural, Lay Cemetery	Gilchrist and Slone (ADS)	75
West Street	Doncaster	Medieval	Urban, Hospital	Bayley and Henderson	3
Wharram Percy	Yorkshire	AD 1348-1540	Rural, Lay Cemetery	Mays 2007	10
Whitefriars	Norwich	AD 1256-1538	Urban, Lay Cemetery	Holst pers. comm.	16
Whitefriars Buttermarket	Suffolk	AD 1278-1538	Urban, Friary	Mays 1991b	3
Whitefriars Canterbury	Kent	AD 850-1550	Urban, Friary	Clough 2006b	7
Wooten Wawen	Warwickshire	AD 1066-1538	Rural, Priory	O'Conner 1975	4

Tab A2: Number and percent of individual pathology in the urban and rural samples, by age.

Category	**6.6-9.9**		**10.0-13.9**		**14.0-16.9**		**17.0-25.0**	
	Urban (%806)	Rural (%142)	Urban (%732)	Rural (%133)	Urban (%641)	Rural (%95)	Urban (%1804)	Rural (%259)
Infection	**57 (7.0)**	**12 (8.4)**	**63 (8.6)**	**15 (11.2)**	**76 (11.8)**	**7 (7.4)**	**258 (14.3)**	**22 (8.5)**
Non-specific infection	43 (5.3)	10 (7.0)	49 (6.7)	13 (9.7)	52 (8.1)	7 (7.4)	194 (10.7)	17 (6.6)
Treponemal	2 (0.2)	0	1 (0.1)	0	4 (0.6)	0	5 (0.3)	1 (0.4)
Leprosy	0	1 (0.7)	5 (0.6)	0	15 (2.3)	0	52 (2.8)	3 (1.2)
Endocranial Lesions	12 (1.5)	1 (0.7)	8 (1.1)	2 (1.5)	5 (0.8)	0	7 (0.4)	1 (0.4)
Trauma	**21 (2.6)**	**3 (2.1)**	**29 (3.9)**	**3 (2.2)**	**39 (6.0)**	**5 (5.2)**	**170 (9.4)**	**18 (6.9)**
Fractures	20 (2.5)	3 (2.1)	26 (3.5)	3 (2.2)	35 (5.4)	5 (5.2)	166 (9.2)	17 (6.6)
Atrophy	1 (0.1)	0	3 (0.4)	0	4 (0.6)	0	4 (0.2)	1 (0.4)
Respiratory Infection	**19 (2.3)**	**7 (4.9)**	**19 (2.6)**	**5 (3.7)**	**32 (5.0)**	**4 (4.2)**	**120 (6.6)**	**11 (4.2)**
Tuberculosis	4 (0.5)	1 (0.7)	4 (0.5)	1 (0.7)	10 (1.5)	0	25 (1.4)	5 (1.9)
Sinusitis	6 (0.7)	2 (1.4)	11 (1.5)	2 (1.5)	8 (1.2)	3 (3.1)	68 (3.7)	5 (1.9)
Rib lesions	9 (1.1)	4 (2.8)	4 (0.5)	2 (1.5)	14 (2.2)	1 (1.0)	27 (1.5)	1 (0.4)
Spine and Joint Stress	**9 (1.1)**	**0**	**19 (2.6)**	**5 (3.7)**	**79 (12.3)**	**6 (6.3)**	**556 (30.8)**	**35 (13.5)**
Joint disease	0	0	0	1 (0.7)	4 (0.6)	1 (1.0)	105 (5.8)	8 (3.0)
OCD	7 (0.8)	0	10 (1.4)	2 (1.5)	16 (2.5)	3 (3.1)	47 (2.6)	7 (2.7)
Schmorl's nodes	0	0	8 (1.1)	0	56 (8.7)	2 (2.1)	361 (20.0)	13 (5.0)
Spondylolysis	2 (0.2)	0	1 (0.1)	2 (1.5)	3 (0.4)	0	30 (1.6)	5 (1.9)
Clay-shoveler's	0	0	0	0	0	0	13 (0.7)	2 (0.7)

Tab A3: Number and percent of individual pathologies in the urban and rural males, by age group

Category	**10.0-13.9**		**14.0-16.9**		**17.0-25.0**	
	Urban (%95)	Rural (%16)	Urban (%184)	Rural (%24)	Urban (%846)	Rural (%105)
Infection	**9 (9.4)**	**2 (12.5)**	**22 (11.9)**	**3 (12.5)**	**129 (15.2)**	**12 (11.4)**
Non-specific infection	6 (6.3)	2 (12.5)	16 (8.7)	3 (12.5)	108 (12.7)	11 (10.4)
Treponemal	0	0	0	0	2 (0.2)	1 (0.9)
Leprosy	1 (1.0)	0	4 (2.2)	0	18 (2.1)	0
Endocranial Lesions	2 (2.1)	0	2 (1.1)	0	1 (0.1)	0
Trauma	**7 (7.3)**	**1 (6.2)**	**18 (9.8)**	**1 (4.2)**	**119 (14.0)**	**4 (3.8)**
Fractures	6 (6.3)	1 (6.2)	18 (9.8)	1 (4.2)	116 (13.7)	4 (3.8)
Atrophy	1 (1.0)	0	0	0	3 (0.3)	0
Respiratory Infection	**2 (2.1)**	**3 (13.0)**	**9 (4.9)**	**0**	**49 (5.8)**	**7 (6.6)**
Tuberculosis	1 (1.0)	1 (6.2)	3 (1.6)	0	8 (0.9)	5 (4.7)
Sinusitis	0	1 (6.2)	2 (1.1)	0	24 (2.8)	2 (1.9)
Rib lesions	1 (1.0)	1 (6.2)	4 (2.2)	0	17 (2.0)	0
Spine and Joint Stress	**5 (5.2)**	**2 (12.5)**	**34 (18.4)**	**1 (4.2)**	**317 (37.4)**	**11 (10.4)**
Joint disease	0	1 (6.2)	1 (0.5)	0	56 (6.6)	1 (0.9)
OCD	3 (3.1)	0	7 (3.8)	1 (4.2)	24 (2.8)	2 (1.9)
Schmorl's nodes	2 (2.1)	0	25 (13.5)	0	215 (25.4)	5 (4.7)
Spondylolysis	0	1 (6.2)	1 (0.5)	0	13 (1.5)	1 (0.9)
Clay-Shoveler's	0	0	0	0	9 (1.2)	2 (1.9)

Tab A4: Number and percent of individual pathologies in the urban and rural females, by age group

Pathology	**10.0-13.9**		**14.0-16.9**		**17.0-25.0**	
	Urban (%77)	Rural (%9)	Urban (%106)	Rural (%11)	Urban (%545)	Rural (%76)
Infection	**3 (3.9)**	**0**	**14 (13.2)**	**2 (18.1)**	**67 (12.2)**	**5 (6.5)**
Non-specific infection	1 (1.3)	0	8 (7.5)	2 (18.1)	55 (10.1)	2 (2.6)
Leprosy	1(1.3)	0	2 (1.8)	0	2 (3.4)	0
Treponemal	0	0	2 (1.8)	0	7 (1.3)	2 (2.6)
Endocranial Lesions	1 (1.3)	0	2 (1.8)	0	3 (0.5)	1 (1.3)
Trauma	**4 (5.2)**	**0**	**6 (5.7)**	**0**	**36 (6.6)**	**7 (9.2)**
Fractures	4 (5.2)	0	5 (4.7)	0	35 (6.4)	6 (7.9)
Atrophy	0	0	1 (0.9)	0	1 (0.1)	1 (1.3)
Respiratory Infection	**3 (3.9)**	**0**	**9 (8.2)**	**0**	**44 (8.0)**	**3 (3.9)**
Tuberculosis	0	0	4 (3.7)	0	10 (1.8)	0
Sinusitis	3 (3.9)	0	3 (2.8)	0	30 (5.5)	3 (3.9)
Rib lesions	0	0	2 (1.8)	0	4 (0.7)	0
Spine and Joint Stress	**1 (1.3)**	**1 (11.0)**	**17 (16.0)**	**1 (9.0)**	**172 (31.5)**	**19 (25.0)**
Joint disease	0	0	1 (0.9)	0	37 (6.8)	7 (9.2)
OCD	1 (1.3)	1 (11.0)	3 (2.8)	0	16 (2.9)	3 (3.9)
Schmorl's nodes	0	0	11 (10.3)	1 (9.0)	109 (20.0)	8 (10.5)
Spondylolysis	0	0	2 (1.8)	0	8 (1.4)	1 (1.3)
Clay-shoveler's	0	0	0	0	2 (3.4)	0

Tab A5: Number and percent of pathology in urban and rural adolescent Pre-AD 1348.

Category	**6.6-9.9**		**10.0-13.9**		**14.0-16.9**		**17.0-25.0**	
	Urban (%356)	Rural (%82)	Urban (%455)	Rural (%88)	Urban (%407)	Rural (%39)	Urban (%1009)	Rural (%243)
Infection (total)	**18 (5.0)**	**10 (12.1)**	**43 (9.4)**	**6 (6.8)**	**42 (10.3)**	**6 (15.3)**	**154 (15.2)**	**10 (4.1)**
Non-specific infection	12 (3.4)	8 (9.7)	36 (7.9)	5 (5.6)	36 (8.8)	6 (15.3)	126 (12.5)	7 (2.8)
Treponemal	0	0	0	0	2 (0.4)	0	0	0
Leprosy	0	1 (1.2)	0	0	0	0	21 (2.1)	3 (1.2)
Endocranial Lesions	6 (1.7)	1 (1.2)	7 (1.5)	1 (1.1)	4 (0.9)	0	7 (0.7)	0
Trauma (total)	**6 (1.6)**	**2 (2.4)**	**24 (5.3)**	**3 (3.4)**	**29 (7.1)**	**4 (10.2)**	**75 (7.4)**	**10 (4.1)**
Fractures	5 (1.4)	2 (2.4)	22 (4.8)	3 (3.4)	28 (6.9)	4 (10.2)	74 (7.3)	9 (3.7)
Atrophy	1 (0.3)	0	2 (0.4)	0	1 (0.2)	0	1 (0.9)	1 (0.4)
Respiratory Infection (total)	**5 (1.4)**	**7 (8.5)**	**9 (1.9)**	**4 (4.5)**	**26 (6.4)**	**0**	**76 (7.5)**	**6 (2.5)**
Tuberculosis	2 (0.5)	1 (1.2)	1 (0.2)	1 (1.1)	10 (2.4)	0	17 (1.7)	4 (1.6)
Sinusitis	0	2 (2.4)	4 (0.8)	2 (2.3)	6 (1.5)	0	39 (3.8)	1 (0.4)
Rib lesions	3 (0.8)	4 (4.8)	4 (0.8)	1 (1.1)	10 (2.4)	0	20 (2.0)	1 (0.4)
Spine and Joint Stress (total)	**5 (1.4)**	**0**	**15 (9.6)**	**4 (4.5)**	**82 (20.1)**	**1 (2.5)**	**394 (39.0)**	**18 (7.4)**
Joint disease	0	0	0	0	4 (0.9)	0	73 (7.2)	3 (1.2)
OCD	4 (1.1)	0	7 (1.5)	2 (2.3)	14 (3.4)	1 (2.5)	26 (2.6)	4 (1.6)
Schmorl’s nodes	0	0	7 (1.5)	0	45 (11.0)	0	273 (27.0)	8 (3.3)
Spondylolysis	1 (0.3)	0	1 (0.2)	2 (2.3)	1 (0.2)	0	22 (2.2)	3 (1.2)

Tab A6: Number and percent of pathology in urban adolescents Post-AD 1348.

Category	**6.6-9.9**		**10.0-13.9**		**14.0-16.9**		**17.0-25.0**	
	Pre (%356)	Post (%82)	Pre (%455)	Post (%69)	Pre (%407)	Post (%53)	Pre (%1009)	Post (%191)
Infection	**18 (5.0)**	**0**	**43 (9.4)**	**2 (2.9)**	**42 (10.3)**	**7 (13.2)**	**154 (15.2)**	**20 (10.4)**
Non-specific infection	12 (3.4)	0	36 (7.9)	2 (2.9)	36 (8.8)	4 (7.5)	126 (12.5)	18 (9.4)
Treponemal	0	0	0	0	2 (0.4)	2 (3.7)	0	2 (1.0)
Leprosy	0	0	0	0	0	0	21 (2.1)	0
Endocranial Lesions	6 (1.7)	0	7 (1.5)	0	4 (0.9)	1 (2.0)	7 (0.7)	0
Trauma	**6 (1.6)**	**3 (3.6)**	**24 (5.3)**	**2 (2.9)**	**29 (7.1)**	**3 (5.7)**	**75 (7.4)**	**33 (19.3)**
Fractures	5 (1.4)	3 (3.6)	22 (4.8)	1 (1.4)	28 (6.9)	2 (3.7)	74 (7.3)	33 (19.3)
Atrophy	1 (0.3)	0	2 (0.4)	1 (1.4)	1 (0.2)	1 (2.0)	1 (0.9)	0
Respiratory Infection	**5 (1.4)**	**0**	**9 (1.9)**	**2 (2.9)**	**26 (6.4)**	**1 (2.0)**	**76 (7.5)**	**10 (5.2)**
Tuberculosis	2 (0.5)	0	1 (0.2)	0	10 (2.4)	0	17 (1.7)	2 (1.0)
Sinusitis	0	0	4 (0.8)	1 (1.4)	6 (1.5)	1 (2.0)	39 (3.8)	8 (4.2)
Rib lesions	3 (0.8)	0	4 (0.8)	0	10 (2.4)	0	20 (2.0)	0
Spine and Joint Stress	**5 (1.4)**	**0**	**15 (9.6)**	**1 (1.4)**	**82 (20.1)**	**9 (16.9)**	**394 (39.0)**	**59 (30.8)**
Joint disease	0	0	0	0	4 (0.9)	0	73 (7.2)	10 (5.2)
OCD	4 (1.1)	0	7 (1.5)	1	14 (3.4)	2 (3.7)	26 (2.6)	2 (1.0)
Schmorl’s nodes	0	0	7 (1.5)	1 (1.4)	45 (11.0)	6 (11.3)	273 (27.0)	44 (23.0)
Spondylolysis	1 (0.3)	0	1 (0.2)	0	1 (0.2)	1 (2.0)	22 (2.2)	3 (1.6)

Footnotes

[i] Shahar 1993; Hanawalt 1993; Heywood 2001; Orme 2008.
[ii] Harlow and Laurence 2002; Hockey and James 1993; Mortimer and Shanahan 2003; Gilchrist 2004.
[iii] Ben-Amos 1994; Pelling 1994; Lane 1996 .
[iv] Moore and Scott 1997; Crawford 1999; Derevenski 1997; Baxter 2005.
[v] WHO 1993
[vi] Cochelin 2013a; 2013b.
[vii] Mays 1999.
[viii] Roberts 2009.
[ix] DeWitte et al. 2013.
[x] Stirland 2005.
[xi] Gholve et al. 2007.
[xii] Stirland 2005.
[xiii] Walker 2012, 155.
[xiv] Dunlop 1912
[xv] Ottaway 1992
[xvi] Dunlop 1912
[xvii] Ibid.
[xviii] Michaud 2007.
[xix] Barron 2007.
[xx] Bitel 2002.
[xxi] Ottoway 1992.
[xxii] Goldberg 1992
[xxiii] Bitel 2002.
[xxiv] Goldberg 2004.
[xxv] Ben-Amos, 1994.
[xxvi] Ibid.
[xxvii] Ibid.

[xxviii] Ibid.
[xxix] Smith 1973.
[xxx] Barron 2007.
[xxxi] Spindler 2011.
[xxxii] Dunlop 1912.
[xxxiii] Ben-Amos 1991.
[xxxiv] Spindler 2011
[xxxv] Thrupp 1948
[xxxvi] Hovland 2006
[xxxvii] Goldberg 1986.
[xxxviii] Poos 1991.
[xxxix] Wareing 1980, 243.
[xl] Pelling 1988.
[xli] Goldberg 1986.
[xlii] Keene 1975.
[xliii] Penn and Dyer 1990.
[xliv] Ben-Amos 1994.
[xlv] Ibid.
[xlvi] Kendall et al 2013.
[xlvii] Roberts et al 2013.
[xlviii] Pelling 1994.
[xlix] Hanawalt 1993.
[l] Ibid.
[li] Goldberg 1986.
[lii] Michaud 2007.
[liii] Ibid.
[liv] Ben-Amos 1994.
[lv] Michaud 2007.
[lvi] Towner and Towner 2000.
[lvii] Alexandre-Bidon and Lett 1999.

[lviii] Ibid., 77.
[lix] Shapland and Lewis 2013; 2014; Lewis et al in press.
[lx] Hanawalt 2000.
[lxi] Ben-Amos 1991.
[lxii] Dunlop 1912.
[lxiii] Hanawalt 2000
[lxiv] Alexandre-Bidon and Lett 1999.
[lxv] Barron 2007.
[lxvi] Ibid., 52.
[lxvii] Spindler 2011.
[lxviii] Ibid.
[lxix] Gordon 1991.
[lxx] Rawcliffe 2005.
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