Children in Need: An Exploration of Child Health and Hospital Provision in Medieval England

Esmé Nadine Hookway

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Abstract

This thesis presents an investigation into the health status of non-adults (<18 years of age) from English later medieval hospital sites (A.D. 1066-1550). Non-adults are rarely referenced in historical documentation relating to medieval hospital sites, and consequently, little is known about their presence within these institutions. For this thesis, existing archaeological and osteological data from 40 hospital sites, containing data on the skeletal remains of a total of 1,506 non-adults, were compiled. These secondary data were explored to identify skeletal indicators of disease, trauma, and general stress experienced by non-adults. Statistical analyses were conducted to explore health status in relation to factors including age and type of hospital (general hospital, leprosaria, and almshouse).

Once the health status of the non-adults was established, three strands of enquiry were conducted. Firstly, familial, social, economic, and environmental influences on the development and health of non-adults during the medieval period, were investigated. Secondly, the role of the medieval hospital in providing spiritual, practical, and medicinal aid to non-adults were explored. Finally, the burial practices employed by hospitals for the interment of non-adults were examined. The health statuses of non-adults from hospital sites were contextualised through comparisons with contemporary parish and monastic cemetery populations. Additionally, historical sources and modern-day clinical studies were utilised to develop an understanding of the progress of certain pathologies, the use of traditional treatments, and differing societal attitudes to disease.

Demographic differences were found between the cemetery populations of different types of hospitals, with higher rates of younger juveniles identified at leprosaria, and greater numbers of adolescents reported from urban general hospitals. Further disparities were identified in the health status of non-adults by age category. Distinctions in burial practices were also discovered between non-adults in different age categories, which may also reflect differences in local customs or beliefs. The findings of this investigation confirm that medieval hospitals were demographically diverse institutions, nonetheless, non-adults were present in many hospitals. The data indicate that many of the non-adults buried in medieval hospital sites were from low socio-economic status backgrounds, and were at an elevated risk of ill health, yet, they received care within hospital institutions and were afforded a respectful and proper burial.

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Chapter 1. Introduction

The hospitals of the English later medieval period (A.D.1066-1550), hereafter referred to as the medieval period, were diverse institutions, founded by both the Church and private individuals. Over 1,200 hospitals were established during this period, varying in physical size, systems of management, admission policies, and resources (Gilchrist, 1995; Huggon, 2018). Their uniting characteristic was their development within the Christian framework of hospitality and the ethos of the Seven Comfortable Acts (or Works of Mercy): feed the hungry, give drink to the thirsty, shelter the homeless, clothe the naked, nurse the sick, visit the imprisoned, and bury the dead (Gilchrist, 1995; Resl, 2008; Keenan, 2017). Medieval hospitals were akin to religious houses and were referred to in Latin as *domus dei*, literally, the house of God (Orme and Webster, 1995). The term ‘hospital’ is derived from the Latin, *hospitale*, and the Christian concept of providing hospitality to visitors (Huggon, 2018). The principal function of hospitals was the provision of charitable relief in the form of both physical and spiritual care for the sick and the poor, and those unable to maintain their own health and welfare (Rawcliffe, 1984).

The concept of the hospital as an autonomous institution, physically independent of the monasteries, was introduced to England following the Norman Conquest of A.D. 1066 (Gilchrist, 1995). Lanfranc, the Norman Archbishop of Canterbury, is credited as establishing the first two hospitals in England in A.D. 1085, one for lepers, approximately a mile from Canterbury, and another for people with various infirmities, located just outside the town walls (Orme and Webster, 1995; Resl, 2008). New hospital foundations then flourished across England during the 12th and 13th centuries (Watson, 2006). This occurred as a practical response both to the social concerns caused by increasing rates of leprosy, and to religious concepts of charity, in which making provisions for the poor was a means by which the wealthy could find salvation in the afterlife (Resl, 2008). Due in part to the stigma attached to the words ‘leper’ and ‘leprosy’, the condition is known today as Hansen’s disease (Rawcliffe, 2006). However, as Rawcliffe (2006) argues, within a discussion of the disease in the medieval period, the terms ‘leper’ and ‘leprosy’ are appropriate as these terms were in standard usage, and it is within this medieval context the terms are applied herein.

The different types of medieval hospital foundations have been categorised by scholars in various ways according to their specialised functions and the classification of their inmates (see Gilchrist, 1995). The variations in terminology used to describe hospital institutions can be identified in surveys from the 15th and 16th centuries compiled by antiquarians and topographers such as William Worcester (A.D. 1415-1485) and John Leland (A.D. 1503-1552) (Orme and Webster, 1995). In these accounts, buildings which are categorised as medieval hospitals today, were referred to as chapels, colleges, or 'spitals' (*ibid*.). Four categories are typically employed today in discussions of medieval hospitals: infirmaries catered for the sick and the poor, leprosaria housed people with leprosy, almshouses provided long term accommodation for the elderly and poor, and hospices sheltered pilgrims and travellers (Knowles and Hadcock, 1953; Carlin, 1989; Gilchrist, 1995; Orme and Webster, 1995). In their work on English monastic sites, Gilchrist and Sloane (2005) identified three classifications of hospitals based on cemetery demographics: infirmaries, leprosaria, and almshouses. It is these three categories which are used hereafter in this thesis, although infirmaries are referred to as 'general' hospitals as they catered not only for the sick, but in some instances also provided hospitality to travellers, pilgrims, orphans, and the elderly poor. There was undoubtedly a cross-over of functions within hospitals (Watson, 2006). For example, some leprosaria housed non-leprous individuals, such as St Mary Magdalene, King's Lynn (Norfolk), where only three of its 13 inmates were recorded as leprous in A.D. 1174 (Roffey, 2012). Certain general hospitals, such as St Mary Spital, London, which typically provided short-term accommodation, also housed corrodians, pensioners whose retirement was secured within the hospital by payments from an employer or benefactor (Connell *et al.,* 2012). Hospitals were not static institutions but changed in relation to circumstances (Rubin, 1989; Sweetinburgh, 2004). The economic and social turbulence of the 14th century, coupled with a decline in the demand for hospital places, resulted in the closure of many hospitals, whilst others were re-founded, often with a change in function, for example, from a leprosarium to an almshouse (Gilchrist, 1995; Sweetinburgh, 2004).

The location of hospitals was determined, to an extent, by their initial function. Most of the general hospitals and almshouses of the medieval period were situated within towns or just outside city gates, where land was more freely available (Harward *et al*., 2019). A growing economy and increasing population through the 12th and 13th centuries, resulted in an expansion of urban centres, and a subsequent greater demand for hospital places in these densely populated areas (Gilchrist, 1995). Institutions that provided accommodation for travellers and pilgrims, and others such as traders, who could not enter a town at night after the gates had been locked, were frequently located on the peripheries of towns and routes between towns (Orme and Webster, 1995). Hospitals were also founded in rural areas where they served the local communities in addition to travellers. The locations of leprosaria bore a relationship to towns in that they were often constructed on main routeways into towns but were typically situated at a distance from urban centres (Gilchrist, 1995; Roffey, 2012). This may be explained by medieval documentary sources which stress the belief that lepers should be kept apart from the healthy (Rawcliffe, 2006). Henceforth, the three terms ‘urban’, ‘rural’, and ‘marginal’ are employed in this thesis to describe hospital locations.

Due to the complexities of navigating the numerous and diverse nature of the institutions which were founded, there have been few comprehensive studies of the English medieval hospital (Resl, 2008). Rotha Mary Clay’s (1909) volume was the first to focus on the subject, and although the work has since been criticised for being “romantic” and “unscholarly” (Carlin, 1989: 21), it did draw attention to a hitherto neglected area of English medieval history. A second work, by Orme and Webster (1995), synthesising the origins, functions, organisation, and resources of English hospitals, was not produced for nearly another 80 years. In recent decades, calls for an integrated study of the medieval hospital by Horden (1988) and Granshaw (1989), have been addressed. The roles of medieval hospitals have been considered in relation to social poverty and charity (Rubin, 1987; Sweetinburgh, 2004; McIntosh, 2012), to medical practices (Bowers, 2007), and to their association with monasteries and religious practices (Gilchrist, 1995; Watson, 2006). Archaeology is contributing to a growing body of evidence about the physical organisation and resources of hospitals, and the material remains of medical practices (Huggon, 2018). The increasing number of archaeological excavations at medieval hospital sites is providing a wealth of new information on individual sites and their place within society.

Typically, less is known about the inhabitants of hospitals. Inmates are rarely referenced in historical documents, although there are exceptions. For example, foundation charters often stated the number and category of inmates a hospital was designed to cater for (Rubin, 1987). Occasionally more detailed lists of inmates were made during inspection visits, and bequests to inmates are recorded in wills

(Orme and Webster, 1995). It is very rare that named individuals are documented as inmates, although records do exist of individuals who were resident as corrodians (Sweetinburgh, 2003). Consequently, hospital inmates are often discussed in terms of general social groups, categorised by sex, social rank, or occupation (Orme and Webster, 1995). The general absence of children from medieval hospital documents, resulted in Orme and Webster (1995: 111) stating that with the exception of infants and scholars, "children seem to have been rare in hospitals on a long term-basis". The emerging evidence from archaeological excavations and osteological analysis, appears to contradict this statement, as relatively high proportions of children have been identified in some hospital cemeteries: non-adults formed between 20% and 64% of the cemetery populations in 12 of the hospital sites considered herein. The intention of this thesis is to enhance the current understanding of the presence of children in medieval hospitals, by using a bioarchaeological approach to explore their lived experiences.

1.1 Aims and Themes

The primary aim of this research is to explore the health status and thereby the implied social and economic status of non-adults identified at English medieval hospital sites. An examination of the pathologies and trauma experienced by non-adults can indicate if they were likely to be of low socio-economic status, which made them more susceptible to requiring hospital charity and care. The main sources of evidence used to achieve this aim are the published and grey literature archaeological reports, and secondary osteological data relating to non-adults from medieval hospital sites. This information will be contextualised through the use of scholarly literature on the medieval period, palaeopathology research, and modern-day studies of child health. Studies into the health and diseases of present-day non-adults cannot be directly compared to medieval populations as they are from different societies with differing social structures, environments, economies, and medical knowledge (Roberts and Manchester, 2010). However, these studies are important as a means of broadening our understanding of causes of illness and disease, and approaches to healthcare. These multiple strands of evidence can then be pulled together to enhance our understanding of the lives and deaths of the non-adults who were buried at medieval hospital sites.

Three main research themes run through this thesis. The first is an exploration of the social, economic, and environmental factors which could have resulted in a non-adult entering a hospital. Osteological analysis of skeletal remains can identify changes to the bone which are a consequence of certain diseases or trauma a person has experienced in life (Mays, 2010a). The use of bioarchaeology provides an important avenue into understanding trends in health and disease in past populations, although it needs to be stated that many pathologies are acute and a person will die before any skeletal lesions are formed, and many will only effect soft tissue and therefore leave no trace on the skeleton (Roberts and Manchester, 2010). The World Health Organisation (2006a: 1) has, since 1948, defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". This definition has been criticised by Huber *et al*. (2011) for being impracticable, too static, and unmeasurable. Huber *et al*. (2011: 2) suggest an alternative concept of health "as the ability to adapt and self-manage, in the face of social, physical, and emotional challenges". This encompasses aspects of mental, physical, and social health, and an individual's capacity to adjust in order to maintain a sense of wellbeing. It is this latter framework which is considered in this thesis when references to 'health' are made, as it enables the physical health of non-adults from hospital sites to be considered, within the context of factors which contribute to health, and a non-adult's abilities to function within society. As all the individuals considered in this thesis did not reach maturity, they were, arguably, non-survivors, who were not able to adapt to their environment. A child's health status is determined by multiple factors, including the pre-existing health and nutritional status of the mother (Gowland, 2015). The social and economic situation into which a child is born can dictate the availability of adequate food, shelter, and the degree of adult care and supervision (Hanawalt, 1993; Orme, 2001). Differing environmental factors, such as access to outdoor spaces and sunshine, or conversely, exposure to high levels of pollution, will also influence an individual's general level of health (Rawcliffe, 2013). These elements combine to determine the degree to which a non-adult could have received familial support, acted independently, or required the assistance of a hospital.

The second theme relates to the roles of medieval hospitals and the care they provided to non-adults. Archaeological and historical evidence will be used to explore the resources a hospital would have had at its disposal. The fortunes of many hospitals waned over time (see Chapter 2), and this would have impacted on the number of people admitted and the level of practical care that could be given

(Carlin, 1989). However, hospitals often had their own gardens, producing herbs, fruits, and vegetables, and kept livestock which, when managed effectively, could have supplied inmates with a nutritious diet (Rawcliffe, 2008). Hospitals in England, unlike their counterparts on the Continent, did not typically employ professional medical practitioners (Horden, 2007). Even so, staff would have acquired medical knowledge through their experiences of caring for the sick and infirm (Orme and Webster, 1995). Undoubtedly, the religious aspects of hospitals, and the cure of a sick soul, was a priority for those living and working in these institutions (Gilchrist, 1995; Horden, 2007). A consideration of the health status of non-adults and the resources available to hospitals, will be employed to develop an understanding of the needs of non-adults and the care that they could potentially have received in medieval hospitals.

Finally, the third theme in this research is the exploration of burial practices employed by hospitals for non-adults. The locations of burials within cemeteries and chapels, the use of burial furniture such as coffins, and the placement of stones around the head, are often associated with age and social status (Gilchrist, 2012). The custom of multiple burials, and deviant or non-conformist burials will be considered to explore social and religious beliefs in relation to burial practices. An examination will also be made of any differences in intra-site burial practices, and comparisons made with the interments of non-adults in parish and monastic cemeteries. This will provide an insight into the attitudes of those who conducted the burials of non-adults in hospital cemeteries and chapels and ascertain whether non-adults buried within these locations were afforded the same rites as those buried in contemporary parish and monastic cemeteries.

1.2 The Hospital Sites

Huggon (2018) has estimated that 1,146 hospitals were founded in England during the medieval period, approximately 5% of which, have been archaeologically excavated. Of these excavated hospitals, human skeletal remains were reported from 40 sites, 27 of which contained non-adult skeletal remains; these hospitals form the basis of the investigations in this thesis (Table 1.2.1).

Table 1.2.1 Medieval Hospital Sites Collated for this Thesis.

Site No.	Site Name	Foundation and Closure Dates (A.D.)	Hospital Type	Location	Key Reference
1	St Bartholomew, Bristol, Avon	1234-1531	General	Urban	Price and Ponsford (1998)
2	St Bartholomew, Newbury, Berkshire	1200-1554	General	Urban	Clough and Witkin (2006)
3	St Margaret, High Wycombe, Buckinghamshire	1229-UN	Leprosarium (male)	Marginal	Farley and Manchester (1989)
4	St John the Evangelist, Cambridge, Cambridgeshire	1195-1511	General	Urban	Cessford (2015)
5	St Margaret, Huntingdon, Cambridgeshire	1150-1341	Leprosarium	Marginal	Mitchell (1993)
6	St Leonard, Peterborough, Cambridgeshire	1125-1535	Leprosarium, later General, Almshouse (male)	Marginal	McComish *et al.* (2017)
7	St John the Baptist, Chester, Cheshire	1190-1644	General	Urban	Poole (2012)
8	St Mary of the Peak, Castleton, Derbyshire	12th C.-1542	General	Rural	Bloxham (2013)
9	St Leonard, Chesterfield, Derbyshire.	1171-1547	Leprosarium	Marginal	Witkin (2000)
10	St Nicholas, Lewes, East Sussex	1085-1547	Leprosarium, later General	Marginal	Barber and Sibun (2010)
11	Crouched Friars, Colchester, Essex	1235-1538	Leprosarium, later Almshouse	Marginal	Benfield and Brooks (2007)
12	St Mary Magdalen, Colchester, Essex	1100-1565	Leprosarium	Marginal	Crossan (2004)
13	St Mary and St Thomas, Ilford, Essex	1140-today	Leprosarium (male)	Marginal	Ingram (2006)
14	St Margaret, Gloucester, Gloucestershire	1150-1518	Leprosarium, later Almshouse	Marginal	Evans (2006)
15	St John the Baptist, Lechlade, Gloucestershire	1228-1472	General	Marginal	Gloucestershire County Council HER (2008)
16	St Mary Magdalene, Winchester,	1158-1643	Leprosarium, later General	Marginal	Roffey and Tucker (2012)

Site No.	Site Name	Foundation and Closure Dates (A.D.)	Hospital Type	Location	Key Reference
	Hampshire				
17	St Mary Magdalene, Baldock-By-Pass, Hertfordshire	1200-1307	Leprosarium (male)	Marginal	Thorpe *et al.* (2003)
18	St John the Baptist, Berkhampsted, Hertfordshire	1216-1540	Leprosarium	Marginal	Maher (2014)
19	St Peter, St Paul, and St Thomas the Martyr, Maidstone, Kent	1244-1547	General, later Almshouse	Urban	Henderson and Knight (2013)
20	St Stephen and St Thomas, New Romney, Kent	1190-1481	Leprosarium, later General	Marginal	Holman (2008)
21	St John, New Romney, Kent	14th C.-1495	General	UN	Holman (2008)
22	St Mary (Maison Dieu), Ospringe, Kent	1232-1516	General	Rural	Smith (1979)
23	St John the Baptist, Lutterworth, Leicestershire	1218-1546	General	Rural	Priest and Chapman (2002)
24	St Mary Magdalene, Partney, Lincolnshire	1115-1318	General	Rural	Atkins and Popescu (2010)
25	St Giles, Lincoln, Lincolnshire	1275-1453	General	Marginal	Allen Archaeology (2012)
26	St Mary Spital, London, Middlesex	1197-1538/40	General	Urban	Connell *et al.* (2012)
27	St Bartholomew, Castle Acre, Norfolk	12th C.-1350	Leprosarium	UN	Wells (1967).
28	St Giles, Brompton Bridge, North Yorkshire	12th C.-15th C.	General	Rural	Cardwell (1996)
29	St Mary, Staxton, North Yorkshire	12th/13th C.-pre-1535	UN	Rural	Brewster (1951)
30	St Mary, York, North Yorkshire	1318-1535	Almshouse (poor priests)	Urban	Richards *et al.* (1989)
31	St Leonard, Newark, Nottinghamshire	1125-1640	Leprosarium (male), later Almshouse (male)	Marginal	Bishop (1983)
32	St Mary Magdalene, Bawtry, South	13th C.-1685	General	Urban	McIntyre and Hadley (2012)

Site No.	Site Name	Foundation and Closure Dates (A.D.)	Hospital Type	Location	Key Reference
	Yorkshire				
33	St James, Doncaster, South Yorkshire	1222-1547	Leprosarium, later General	Marginal	Buckland *et al.* (1989)
34	St John the Baptist, Lichfield, Staffordshire	1135-1571	General, later Almshouse	Urban	Goacher *et al.* (2016)
35	St John, Stoke-on-Trent, Staffordshire	UN-1545	UN	UN	Duncan (2002)
36	St Peter, Bury St Edmunds, Suffolk	1135-1538	General (aged or sick priests)	Marginal	Brooks (2012)
37	St Saviour, Bury St Edmunds, Suffolk	1184-1539	Almshouse (priests, male)	UN	Caruth and Anderson (1997)
38	St Leonard, Coventry, Warwickshire	Mid-12th C.-1280	Leprosarium	UN	Palmer (2007)
39	St Mary Magdalene, Bidlington, West Sussex	13th C.-16th C.	Leprosarium (male), later Almshouse	Rural	Lewis (1964)
40	St James and St Mary Magdalene, Chichester, West Sussex	1118-1621	Leprosarium (male), later Almshouse	Marginal	Magilton *et al.* (2008)

1.2.1 A Synopsis of the Hospital Cemetery Excavations

The earliest recorded archaeological excavation of a burial ground associated with a medieval hospital was conducted by Mr Wentworth Sturgeon *c.* A.D. 1900. Over 40 human skeletal remains were identified during the excavation and were thought to be related to the medieval hospital of St John, Lechlade (Gloucestershire) (Gloucestershire HER, 2008). Between one and four hospital cemetery sites were subsequently excavated each decade from the 1950s to 1990s (see Chapter 4 Table 4.1.1). Nearly half (n = 19, 47.5%) of the sites considered in this thesis have been excavated since 2000. A total of seven (17.5%) sites were excavated in two discrete episodes of investigation, with excavations at Crouched Friars, Colchester (Essex), separated by over 20 years (Crummy *et al.*, 1993; Benfield and Brooks, 2007). The developments in archaeological practice over the past century have inevitably resulted in a variety of methods and expertise utilised in the excavations. Additionally, constraints imposed on excavations, in relation to funding, time, the availability of specialists, and the physical extent of the archaeological project area, all impact the scope and detail of the knowledge produced through each investigation.

The majority (n = 33, 82.5%) of excavations collated for this current research were conducted for commercial purposes, ahead of construction (see Table 4.1.1). Of the remaining seven sites, five (12.5%) excavations were run as university research projects, with the aims of investigating known medieval hospital sites. Differences in the reasons for excavation have resulted in diverse quantities of information from each of the archaeological projects. For instance, the landscaping of domestic gardens in Chesterfield (Derbyshire), and Bury St Edmunds (Suffolk), resulted in the chance discovery of human skeletal remains which were subsequently identified as burials relating to medieval hospitals (Witkin, 2000; Brooks, 2012). These excavations were, by their nature, restricted in physical size and consequently the information which can be gleaned from them is limited. Additionally, surviving historical documentation related to hospital sites can be slight or ambiguous. During archaeological works in Stoke-on-Trent (Staffordshire), the location under investigation was thought to be that of the hospital of St John. However, the historical documentation was vague and referred to different dedications, possibly indicating a change in the dedication of a single institution or, the existence of several hospitals within the same area (Duncan, 2002). Although human skeletal remains were recovered during the excavation, they were too poorly preserved to obtain any osteological information (Brickley, 2002).

Other commercial archaeology projects were extensively planned in advance of construction. The redevelopment of Spitalfields Market, London (Middlesex), and housing developments in Chichester (West Sussex), provided opportunities for large scale archaeological excavations and post-excavation analysis at the sites of the medieval hospitals of St Mary Spital, and St James and St Mary Magdalene, respectively (Magilton *et al*., 2008; Harward *et al*., 2019). The most comprehensive study of a medieval hospital to date is that of St Mary without Bishopsgate, also known as 'St Mary Spital', London (Thomas *et al*., 1997, Connell *et al*., 2012, Harward *et al*, 2019). During excavations by Museum of London Archaeology (MOLA) at the Spitalfields Market, London, between 1991 and 2007, many of the buildings in the priory precinct were uncovered and a total of 10,516 human skeletons were excavated (Connell *et al*., 2012). This is the largest excavation of a cemetery in Britain and 5,387 of the skeletons were osteologically analysed (*ibid*.). The extent of the excavation and post-excavation work has provided a unique insight into the lives of people who were buried at this site, and the functions of this medieval hospital. As aforementioned, the diverse character of medieval hospitals does make it difficult to generalise about their functions. However, these larger scale excavations and subsequent osteological analysis, do provide important insights into the activities of hospitals, and the demographic and health status of hospital inmates. These data indicate social and religious attitudes towards the sick and poor, and those who were permitted entry into hospitals. In turn, an understanding of these attitudes can be used to gauge who the inmates were of less well documented or researched hospitals.

1.2.2 A Synopsis of The Hospital Sites

The current information available for each hospital site varies considerably, dependant on the survival of historical documentation, the extent of archaeological excavations, and the degree of osteological analysis that could be conducted at the time of the excavation. Hence, in order to impart a summary of the 40 sites utilised in this thesis, the following synopsis draws on the similarities and common features of the hospitals, whilst highlighting any important discrepancies in individual sites. A summary of each individual site, along with the demographic information obtained from osteological reports can be found in Appendix 1. The hospital sites considered in this present research are all located within England, predominantly within central and eastern areas (see Chapter 4, Figure 4.1.1).

Of the hospitals with a known foundation date, the majority (n = 23, 57.5%) were founded in the 12th century, and 13 (32.5%) in the 13th century (Table 1.2.1). St Nicholas, Lewes (East Sussex), is the earliest hospital foundation and is thought to have been established shortly after Lanfranc's Canterbury hospitals (Barber and Sibun, 2010). Only two (5.0%) of the hospitals examined in this research, St John, New Romney (Kent), and St Mary, York (North Yorkshire), were established in the 14th century. The mixed fortunes of hospitals are reflected in the 40 sites compiled herein: six (15%) sites were re-founded during the 14th century and a further ten (25%) were officially dissolved or effectively ceased to function throughout the 13th and 14th centuries. A total of seven (17.5%) hospitals survived the Dissolution of the Monasteries in the A.D. 1530s and continued into the post-reformation era.

The 40 hospitals under study in this present research are representative of the wider body of known founders. Whilst the founders of 21 (52.5%) hospitals are unknown, historical records indicate 19 of the hospitals were founded by either royalty (n = 3, 7.5%), bishops and abbots (n = 5, 12.5%), or the aristocracy and notable citizens (n = 11, 27.5%) (Table 4.1.1). Only two hospitals, St Mary Spital, London, and St Mary, Staxton (North Yorkshire) are documented as dependents of an Augustinian priory, although five others followed the Augustinian rule. A further nine hospitals were dependants of abbeys or priories of the Benedictine Order. Two further religious orders, the Order of the Holy Cross and the Order of St Thomas the Martyr of Acon, are each associated with the founding or management of two hospitals included in this current study.

The size of nine (22.5%) hospitals under consideration are unknown, however 19 (47.5%) are recorded as being of a typical size, housing a dozen or so inmates (Table 4.1.1) (Orme and Webster, 1995). An additional three (7.5%) medium sized hospitals are thought to have accommodated around 20 people, although whether this was the number of inmates or inmates and staff combined is not always clear. Smaller hospitals, which often catered for fewer than six inmates, are represented by eight (20.0%) of the hospital sites. Of these, four were rural hospitals which often provided accommodation for a single night to travellers and pilgrims. St Mary Spital, London, is the only larger hospital included in this thesis, and few hospitals of this size existed in medieval England (Orme and Webster, 1995) (see Chapter 2). Following expansions in the 13th and 14th centuries, St Mary Spital had space for 140 beds (Harward *et al*., 2019). The hospital possibly accommodated twice this many inmates during periods of increased demand, for example during outbreaks of infectious disease, if the beds were pushed together, as occurred in larger hospitals on the Continent, such as the Hôtel-Dieu de Paris (France) (Thomas *et al*., 1997).

1.3 Thesis Structure

This thesis continues in Chapter 2, with an overview of English medieval society, considering family structures, living environments, work, and attitudes to the poor, to contextualise the lives of children during the medieval period. The founding of hospitals is examined, together with hospital admission policies, their provisions for inmates, and the daily lives of inmates. Archaeological approaches to the study of non-adults will be explored, reviewing the development of childhood studies, and evaluating methods of identifying non-adults within archaeological practices. Subsequently an appraisal of bioarchaeological methods and theories will be made in Chapter 3, highlighting advances in approaches to age determination of non-adults and the identification of pathologies and trauma.

Chapter 4 details the methodologies used in this thesis to identify and collate the historical, archaeological, and osteological data pertaining to each of the 40 hospital sites under consideration. The rationale is stated for the methods used to create a database and standardise data from different osteological reports. Consideration is given to the limitations inherent in the use of numerous archaeological and osteological reports, produced to varying standards over the past 100 years. The descriptive data and results of statistical analysis are presented in Chapter 5. An assessment of the demographic profiles of hospital cemeteries is made, and the results of statistical analysis are stated, identifying any relationships between demographic patterns, the locations of hospitals, and the presence of disease, trauma, and general stress indicators. An appraisal of burial practices is also made.

A discussion of the results is set forth in Chapter 6. The results of the statistical analysis will be considered within the context of wider literature and the three main themes of this thesis: firstly, the lived experiences of non-adults during the medieval period and the social, economic, and health risks which may have resulted in them entering a hospital. Secondly, the spiritual and physical care offered by hospitals, and finally, the burial of non-adults by hospital institutions. The key findings and themes of the discussion will then be summarised in Chapter 7, the concluding chapter of this thesis. Limitations of this research will also be noted, and recommendations made for further work, building on the findings and conclusions of this thesis.

1.4 Summary

This chapter has introduced the medieval hospital and its development within English society following the Norman Conquest in A.D. 1066. The research aims and thematic structure of this thesis were stated, outlining how existing osteological data, archaeological research, and historical studies will be used to garner an understanding of the lives and deaths of non-adults from medieval hospital sites. The hospital sites utilised in this research were presented, with a summation of the data obtained for each site. The following chapter will review the current literature concerned with English medieval life, the role of the hospital in medieval society, and the theoretical and methodological advances within the archaeological discipline related to childhood studies.

Chapter 2. English Medieval Life, the Medieval Hospital, and the Medieval Child

English medieval hospitals were created within medieval social, religious, and economic environments. Except for babies and young children who may have been born in, or abandoned, at a hospital, the majority of inmates were born in family homes, and lived and worked in environments which influenced their health. Therefore, this chapter begins with an overview of the medieval population and life during this period. Following this, the foundations and functions of hospitals will be explored. Subsequently, academic approaches to the study of childhood during the medieval period are considered.

2.1 Medieval Life

The 'life course' theoretical framework is used in biological and social sciences as a means of exploring individuals lives within their socio-economic and historic contexts (Agarwal, 2016). Life course approaches consider an individual as a cumulative entity, embodying experiences from before birth to death, and acknowledges the fluidity of social identity related to age (Gowland and Penny-Mason, 2018). This framework can be used to interrogate interrelated, inter-generational experiences to understand the life course at a community level (Agarwal, 2016). Gowland (2015) argues that to understand the individual life course, it is necessary to understand the individual as embedded within a community whose physical environment, socio-economic status, diet, and genetics have implications through successive generations. Thus, an overview of social, economic, and environmental factors in the medieval period is presented below to contextualise the lived experiences of non-adults. The focus here is on the poor in society as they were typically the recipients of hospital charity, however as Hanawalt (2005: 1069) states, the poor are "underrepresented and voiceless" and consequently, are hard to write about.

2.1.1 The English Medieval Population

Estimates of the English medieval population have been calculated by scholars based on the Domesday Book, wage accounts and tax returns, and manorial records (Lee, 1973; Clark, 2007; Broadberry *et al*., 2011). These records were primarily produced for financial purposes, and consequently, population estimates derived from them vary due to academic assumptions of record omissions and multiplication rates for households (Broadberry *et al*., 2011). Nonetheless, trends in population expansion from A.D. 1100-1300, contraction during the 14th century, and fluctuations through the 15th century, can be ascertained (Schofield and Vince, 2003).

The Domesday survey, conducted following the Norman Conquest of England in A.D. 1066, suggests that the English population numbered 1.5-2 million people. Over 90% of the populace lived in rural settlements, and over 100 towns with 2,000-10,000 inhabitants are listed in Domesday (Campbell, 2008; Thomas, 2008). The 12th and 13th centuries were periods of economic prosperity and growth, which advanced the expansion of towns (Schofield and Vince, 2003). The population increased during this period, to between four and six million people, 600 new towns were established, and the urban population increased to 20% (Campbell, 2008; Bailey, 2021). The population of London is estimated to have grown to 60,000-80,000 inhabitants (Campbell, 2008). The turn of the 14th century witnessed economic decline: high taxes, population pressures, and small peasant landholdings, insufficient to sustain families, resulted in migration to towns where high food prices, high unemployment, and low wages, gave rise to high levels of poverty (Bailey, 2021).

Climatic deterioration at the beginning of the 14th century, contributed to famines across Europe from A.D. 1310, culminating in the Great Famine of A.D. 1315-1317, which reduced the English population by approximately 10% (Lewis, 2020). The Black Death in A.D. 1348-1349, caused further population decline, the exact degree of which is debated, although current estimates suggest a mortality rate of 40-60% (Lewis, 2020; Bailey, 2021). Social and economic changes in the aftermath of the Black Death were complex, and whilst not universal, an improvement in living standards occurred in the latter 14th and 15th centuries as employment opportunities increased and wages rose (Clark, 2007; Bailey, 2021). Population levels fluctuated throughout the 15th century, only recovering to consistent levels in the 16th century (Clark, 2007; Lewis, 2020). Causes of the continuation of low population levels are disputed, though attributed to high mortality rates caused by repeated outbreaks of plague, or low birth rates as increasing numbers of women entered the labour market (Broadberry *et al*., 2011; Lewis, 2020).

2.1.2 Early Family Life

With the development of small-scale peasant farming in the latter half of the 11th century, family structures evolved from the earlier medieval (A.D. 410-1066) extended kin groups, into nuclear units comprising a coresident couple and their children (McCarthy, 2004; Gilchrist, 2012). Tax records, manorial records, and wills indicate medieval family structures and size (Hanawalt, 1986). They often omit women and children under 12 years of age, yet scholars agree that most peasant households included one to three live children (Hanawalt, 1986; Orme, 2001; Schofield and Vince, 2003). Birthing was considered a time of danger for the mother and baby (Gilchrist, 2012). Births and deaths were not routinely recorded, thus, establishing mortality rates is problematic (Orme, 2001; Lewis and Gowland, 2007). Estimates of infant mortality rates vary from 20% (Gilchrist, 2012), and 27% (Orme, 2001), to 30-50% (Hanawalt, 2002). Baptism was seen as a crucial rite, ridding a new-born of Original Sin and, if the baby died, allowing it entry into heaven (Orme, 2001). Church laws permitted midwives to conduct emergency baptisms, possibly indicating a high mortality rate and fear for a new-born's soul (Orme, 2001; Gilchrist, 2012).

For children who survived birthing, mothers were their primary caregivers, and Orme (2001) portrays a caring home environment for infants, with mothers singing lullabies and teaching children rhymes. Medieval imagery and poetry further illustrate children at play, with a variety of games and toys (Hanawalt, 1993; Orme, 2001). However, for children born into poverty, early life could be harsh, and a new baby placed additional strains on a family (Orme, 2001). Mothers who worked in the fields took their children with them, swaddling babies to reduce accidental harm. Yet, coroner's rolls attest to the risks of accidental injury and death for children from three or four years of age, as they started imitating their parents in their work (Hanawalt, 1986). For families in dire poverty, mothers would take their children begging with them, receiving charity and aid in some communities, although neglected and viewed with suspicion in others (Orme, 2001).

Hanawalt (1986) argues that high levels of adult mortality in the medieval period, resulted in stepparents and older siblings inheriting responsibility for orphaned or abandoned children. Alternatively, manorial courts appointed a guardian, often in exchange for the child's inheritance (Hanawalt, 1986). Attitudes to illegitimate children and their mothers were complex and differed between communities. Unwed mothers could be fined by civil courts and made to pay public penance by the Church (Orme, 2001; Lee, 2014). Lee (2014) asserts that a mother's economic status determined social attitudes: women in poverty reliant on charitable support to raise an illegitimate child, were stigmatised and faced social exclusion. Yet, Hanawalt (2002) states that whilst documentary evidence is scarce, existing church and manorial accounts indicate that infanticide or abandonment of infants was rare. Maddern (2012) rejects this, suggesting that women were forced by circumstance to give up their children. Maddern (2012) identified 116 cases of illegitimate children from various English medieval documents, including 11 (9.5%) mothers or children who were resident in hospitals. Boswell (1988) further asserts that poverty and an inability to provide for children, resulted in parents fostering them, placing them in monastic institutions, or from seven years of age, sending them into domestic service.

2.1.3 Urban and Rural Life

In medieval towns and villages, typical single storey houses were made with timber posts, supporting horizontal beams or infilled with wattle and daub, and earthen floors, covered with straw (Dyer, 1989; Gilchrist, 2012; Magnusson, 2013). As the economy grew in the 12th and 13th centuries, construction methods improved, and a greater proportion of rural peasants could afford substantial cruck structured houses with stone foundations (Dyer, 1989; Dyer, 2012c). There was, however, a hierarchy within peasantry, and Dyer (1989: 166) suggests that "flimsy cottages" continued to be the norm for poorer rural smallholders. Clean water was sourced from communal wells or streams, although documented neighbourly complaints and byelaws aiming to control water pollution, illustrate that waste disposal and water pollution were problematic (Dyer, 1989). Dyer (1989) describes rural houses as damp and draughty, with vermin attracted by the thatch roofing; living environments which would have promoted disease. Yet, rural populations benefitted from clean air, low density housing, and relatively sanitary living conditions (Dyer, 2012c).

Wealthier rural peasant families were self-sufficient, producing a range of fruits and vegetables, growing legumes and grains, and consuming dairy produce from sheep, cattle, or goats (Hanawalt, 1986; Dyer, 2012c; Dunne *et al*., 2019). The extent of meat consumption is uncertain, as Dyer (2012c) suggests, animals were valuable to peasants as traction animals or as producers of commodities such as wool, for sale or exchange. Dyer (2012a) estimates 50% of rural households lived on holdings too small to support a family. These poorer peasants produced only a proportion of their food needs and relied on waged labour or craft production for survival (Dyer, 2012b).

As the urban populace grew during the 12th and 13th centuries, housing density increased and larger stone buildings were erected (Schofield and Vince, 2003). However, the houses of the poor have largely been destroyed without leaving any trace (*ibid.*). Exceptionally, one-roomed houses were identified at Winchester, and small two-room houses with clay floors and walls were uncovered at Norwich (*ibid*.). Poor families also rented single rooms above shops, sub-let part of a larger house, or constructed small shacks or lean-tos against existing buildings (Hanawalt, 2005; Gilchrist, 2012). The importance of sanitation and clean water was recognised by town officials, and by the early 13th century towns invested in public latrines, fountains, and wells, and employed sanitation workers (Magnusson, 2013). Yet, access to clean water supplies could be restricted. For example, some wells were located on private property and, as the demand for water increased, charges were introduced, effectively denying access to the poor (Keene, 2001). High density urban populations produced substantial quantities of domestic and industrial waste which contributed to water pollution (Keene, 2001; Schofield and Vince, 2003). As in rural villages, towns had rules governing waste disposal, although Magnusson (2013) suggests that the repetitive issuing of ordnances, raises doubts about their effectiveness.

Small towns sourced food from garden plots and agricultural hinterlands, and thus, Schofield and Vince (2003) suggest, urban inhabitants consumed a diet comparable to rural populations, although, developing urban market economies provided a wider variety of foodstuffs to inhabitants who could afford it (Walker, 2012b). Yet, many urban poor lived in cramped accommodation with no means of producing, preparing, or cooking food and were reliant on purchasing pies or stews from vendors (Hanawalt, 1993, 2005). Bread and ale prices were regulated, although, the urban poor were vulnerable to price fluctuations during times of low product yield and corresponding high demand (Hanawalt, 1993; Walker, 2012b). At these times, their options for obtaining food were limited to the charitable provisions given by the wealthy and monasteries (Walker, 2012b).

2.1.4 Working Life

Orme (2001) proposes four areas of employment for non-adults during the medieval period: the countryside, towns, aristocratic households, and the Church. Children could enter employment from seven years of age, although apprenticeships, which required the employee to live with the employer's household, typically began at 12 to 14 years of age (Orme, 2001). Documentary evidence for lower status work conducted by children is limited, as children under 15 years of age were officially omitted from tax records, and few references exist in manorial court records (Hanawalt, 1986; Dyer, 1989).

Hanawalt's (1986) study of coroner's rolls illustrates the tasks and risks undertaken by children working in the countryside. Between the ages of 6 and 12-years, accidental deaths are recorded for girls who were gathering food and collecting water, whilst boys were fishing, collecting peat, and herding when fatal incidents occurred (Hanawalt, 1986). During adolescence, boys were given greater responsibilities in the fields, whilst girls increased their work around the home, spinning, weaving, brewing, and baking (Hanawalt, 1986; Orme, 2001), although during harvest or haymaking seasons any child old enough to wield a sickle or gather crops, was expected to work (Bardsley, 1999). Following the Black Death, the value and potential of children as agricultural workers increased. The Statute of Cambridge (A.D. 1388) compelled any child with experience of pastoral or arable farming to remain as an agricultural labourer (Dyer, 1989; Bardsley, 1999). Dyer (1989) suggests that, increasingly younger children were employed in occupations previously conducted by adult men, such as ploughing or smithing. This increased the economic value of children's work, yet, placed them at risk if they were physically incapable or not sufficiently experienced to conduct themselves safely.

Towns were attractive for adolescents as they provided a greater variety and number of jobs than rural villages (Orme, 2001). Yet, opportunities for the poorest were limited as many employers demanded a fee prior to the commencement of an apprenticeship (*ibid*.). Barron (2017: 401) argues apprenticeships included "quite poor children", although London regulations stated apprentices should not be the children of villeins or serfs. Consequently, children from poorer families frequently sought menial jobs in towns, or entered domestic service (Hanawalt, 1993; Orme, 2001). Households from middling and upper social status' commonly kept servants, with approximately one-third of York's population working in service (Walker, 2012b). Positions in aristocratic households were prestigious, and servants often came from families of high social status (Hanawalt, 1986). Nonetheless, there was a hierarchy of servants, and many poor children entered aristocratic service in a lowly position (Dyer, 1989). Roles as housemaids or dairymaids were open to girls, and boys could undertake work in the bakeries, kitchens, laundries, and stables (Hanawalt, 1986). Servants could receive a wage, although more often worked 'in kind', receiving bed and board, clothing, and training in return for their labour (Orme, 2001).

The Church provided an alternative career path for children, and offered accommodation, meals, and an education (Orme, 2001). Entry to girls was limited as they could only work in nunneries, whilst boys were useful in cathedrals, colleges, monasteries, friaries, and parish churches (*ibid*.). At entry, children were bound to the Church for a set period of time, although afterwards, they could leave, remain as lay staff, or take vows and commit to the priesthood or a monastic life (*ibid*.). Orme (2001) describes the difficulties the Church had in recruiting new members: lewd behaviour by friars and claims of child abduction, resulted in a statute in A.D. 1402, prohibiting children under fourteen years of age from entering friaries without familial consent. Nonetheless, for children in poverty with few options, the Church could offer a secure future.

2.1.5 Medieval Attitudes to Poverty

Poverty and charity were important religious concepts during the medieval period (Dyer, 1989). It was accepted that the poor existed as part of the natural social hierarchy, however, the Gospels warned that the souls of the wealthy were in immortal danger (Gilchrist, 1995). The Church taught that Purgatory was a place the soul entered after death, where "sins were purged by every kind of physical torment", before redemption was received and souls entered heaven (Gilchrist, 1995: 8). As Rubin (1987: 2) states, "charity bound the rich and the poor together" and thus, the needs of both warrant consideration to understand charity and the medieval hospital. The Church promoted the ideal of a symbiotic charitable relationship: the wealthy gave alms (in the form of food, clothing, fuel, and money), demonstrating their humility and mercy, in return for which the poor accepted charity and prayed for their benefactor (Rubin, 1987; Hanawalt, 2005; Dyer, 2012a; McIntosh, 2012). Debates on the deserving and non-deserving poor were instrumental in the distribution of alms and charity by the church and the laity (Dyer, 1989). Beggars of any age were considered a public nuisance, and it was believed too much charity would encourage idleness and criminality. Alternatively, the humble poor were deemed worthy recipients of charity.

The later 13th century was a period of worsening hardship for many (Rubin, 1987). Attitudes towards the poor were challenged during the 14th century due to the economic, social, and migratory changes brought about by famine and disease. Hanawalt (2005) cites two accounts of men, women, and children being crushed to death during the distribution of alms. Yet, following the Black Death, labour shortages resulted in improved wages and conditions, prompting societal questions about the legitimacy of the poor (Rubin, 1987; McIntosh, 2012). Concurrently, lower production rates meant landowners experienced a tightening of their profits, and hence, had less to give. Whilst the Church still advocated the giving of alms, the notion of poverty as a consequence of sin, came to the fore. Statutes were introduced restricting access to charity, with only people deemed incapable of work were considered the true deserving poor (Rubin, 1987; Hanawalt, 2005; Dyer, 2012a).

Dyer (2012a) suggests, however, a growing concern for the poor is evidenced in the numbers of almshouse foundations, although 15th century wills indicate only 9% of wealthy testators left alms to hospitals and the poor, with more choosing instead to donate to educational institutions or city amenities (Hanawalt, 2005). Guilds often established their own means of raising funds and distributing alms to their members; conscious of the risks of working in dangerous occupations, such funds provided a safety net for members and their families (Rubin, 1987; Hanawalt, 2005). The poor also established their own support networks, providing mutual aid for one another (Horden, 2008). The loss of income or a reduction in harvest yield could quickly result in families finding themselves in perilous circumstances (Dyer, 1989). Records of wills demonstrate that paupers left what little they possessed to others in poverty (Hanawalt, 2005; Dyer, 2012a). As Hanawalt (2005) argues, those most concerned about the poor, were those closest to poverty themselves.

2.1.6 Summary

This review of medieval life has provided a context to the life course of medieval non-adults by considering family life, housing and diet in urban and rural locales, the environments in which non-adults worked, and societal attitudes towards the poor.

Comparatively little historical or archaeological evidence exists for the poor in medieval society (Hanawalt, 2005). However, the available sources suggest life could be harsh for children born into poverty (Orme, 2001). Whether in the town or country, poor families lived in low-quality housing, did not possess enough land to be self-sufficient, and relied on waged labour or begging to meet their basic needs (Dyer, 1989; Hanawalt, 2005; Gilchrist, 2012). Employment opportunities were limited for those without the economic means or social standing to secure an apprenticeship or gain a favourable position of service. Thus, many children from seven years of age undertook menial agricultural tasks or entered domestic service in the households of the urban middling classes (Orme, 2001). The famines and plagues of the 14th century were undoubtedly calamitous, yet, for those who survived, the decline in population offered new opportunities regarding land acquisition and better employment conditions (Clark, 2007; Bailey, 2021). However, changes in attitudes to the poor are also evidenced. Access to charitable support became more restricted and societal perspectives on the deserving and undeserving poor became entrenched (Rubin, 1987; McIntosh, 2012). The following section explores the development and functions of English medieval hospitals, and the daily life and routines of hospital inmates.

2.2 The English Medieval Hospital

English medieval hospitals were diverse institutions, established by monasteries and the laity for differing reasons (Carlin, 1989). Thus, an overview is presented below of key aspects of hospital foundations, forms, and functions common to many, although not all, hospitals (see Hookway and Squires, 2020). Children are rarely mentioned in historical documentation relating to hospitals, however, by considering the intentions of hospital founders, the resources available to hospitals, and the structure of daily life within hospitals, it is possible to gain an insight into the environments and treatment non-adults experienced when they entered a hospital. Finally, attention is given to the hospital's obligation to bury those who died within their care.

2.2.1 Hospital Foundations and Ruinations

Few medieval hospital foundation charters survive to the present day (Watson, 2006; Resl, 2008). Consequently, what is known about founders and their intentions is derived from copies or extracts retrospectively recorded in registers or cartularies (Resl, 2008). Hospital foundations in the 12th and 13th centuries, are associated with the monastic Church and, notably, the Augustinian and Benedictine Orders (Knowles and Hadcock, 1953; Rubin, 1987; Harward *et al.*, 2019). The Augustinians were committed to the service of others, and within a hospital environment, the brethren and sisters could follow a monastic lifestyle, whilst attending to their charitable purposes of caring for the sick and poor (Rawcliffe, 1984; Gilchrist, 1995). The rule of St Benedict decreed that the sick should "be served in the very deed of Christ himself" (Rawcliffe, 2006: 322). The Benedictines incorporated infirmaries into their monasteries in Europe from the 6th century, and in the later medieval period, extended their ethos of caring for the sick beyond the monastery, establishing external hospitals (Retief and Cilliars, 2006). Private patrons donated land and goods to hospitals and increasingly founded their own institutions, often placing them under the control of a monastery (Orme and Webster, 1995; Rawcliffe, 2007). Gilchrist (1995: 13) describes some privately founded hospitals as intercessory "prayer factories": for example, Harvey Beleth, founded a hospital in Norfolk c. A.D. 1181, for 12 poor persons, to pray for himself and his ancestors. Nonetheless, these institutions provided the necessities of food and shelter which were increasingly needed by the poor within a growing urban population (Gilchrist, 1995).

An increase in leprosy during the 11th century or possibly, as Roffey (2012) suggests, changing social attitudes to the disease, initiated many hospital foundations. The marginal location of leprosaria was likely due to the book of Leviticus which stated that lepers should live "outside the camp" (Orme and Webster, 1995; Rawcliffe, 2006: 256). Documentary sources indicate leprosy was feared during the medieval period, although the extent to which lepers were ostracised from society is debated (Orme and Webster, 1995; Roberts, 2002). Ordinances from many towns including London, Bristol, Norwich, and Launceston, which forbade lepers from entering the town on punishment of imprisonment or the forfeit of their possessions, including their clothes (Orme and Webster, 1995). Yet, Jesus had healed lepers, and whilst sin was considered a cause of leprosy, the suffering and penitence of the leper was believed to bring them closer to Christ, bestowing a special status upon lepers, and by extension, their benefactors (Gilchrist, 1995; Rawcliffe, 2006; Roffey, 2012).

During the 14th century, the numbers of new hospital foundations diminished, and many existing hospitals declined (Orme and Webster, 1995). Although the foundations of leprosaria cannot be directly associated with the prevalence of the disease, leprosy waned from the 14th century onwards, and whereas over 300 leprosaria were founded from the 11th-13th centuries, only 17 were established during the 14th-16th centuries (Gilchrist, 1995; Roberts, 2002; Roffey, 2012). The aforementioned turmoil of the 14th century impacted hospital fortunes as their incomes fluctuated as benefactors own financial positions and interests changed (Rubin, 1987, 1989; Price and Ponsford, 1998). Furthermore, the rental income hospitals generated from their own landholdings fell, as land became more widely available (Rubin, 1989). Hospitals which followed a religious rule and were staffed by monks or nuns were directly impacted by the Dissolution of the Monasteries in the 1530's (Orme and Webster, 1995). Hospitals could survive this period, dependant, in part, on the value attributed to their charitable works. A parliamentary bill of A.D. 1539, deemed that sites which provided locally needed charity and education, could continue into the post-reformation era (*ibid*.). For instance, St John, Chester (Cheshire), and St Leonard, Newark (Nottinghamshire), continued to function due to their roles in education and social welfare (Bishop, 1983; Orme and Webster, 1995; Poole, 2015).

2.2.2 Hospital Forms and Organisation

Most small towns had at least two hospitals, one for the leprous and one for the sick poor, whilst larger towns such as London and York had over 30 institutions (Orme and Webster, 1995; Price and Ponsford, 1998). Typically, English hospitals were built to accommodate 12 inmates, signifying an association with the 12 apostles, with a master, and two or three resident brothers or sisters to administer to the inmates (Gilchrist, 1995; Orme and Webster, 1995). Many hospitals were constructed around a monastic style cloister, with separate buildings for staff and inmates, and adjacent gardens and outbuildings for brewing and baking (Gilchrist, 1995). Smaller hospitals consisted of a single dwelling house or group of cottages, accommodating fewer than six inmates (Orme and Webster, 1995). Compared to other European countries, particularly France and Italy, few larger hospitals were founded in England. The largest was St Leonard's, York, established for approximately 200 inmates, followed by St Mary Spital, London, which, following expansion in the 14th century, is estimated to have had space for 140 beds (Rubin, 1989; Orme and Webster, 1995; Harward *et al*., 2019).

Male and female inmates were segregated and placed into different dormitories within hospitals, or separated by screens (Orme and Webster, 1995; Thomas *et al*., 1997; Price and Ponsford, 1998), although, hospitals were often founded for inmates of a single sex, for example, the leprosarium of St Margaret, High Wycombe (Buckinghamshire), was founded for men only, and St Mary, York, was established for poor priests (Farley and Manchester, 1989; Richards *et al*., 1989). A parliamentary statute of A.D. 1414 listed people hospitals should support, which included pregnant women. Yet, lewd pregnant women were explicitly excluded at St John, Cambridge (Cambridgeshire) (Cessford, 2012). Bridge (1999: 140) suggests such discrimination was based on ideals of morality, and the fear that "lewd" women would be a temptation to the brothers and distract inmates from prayer. The term 'lewd', may refer to prostitutes who were considered "a threat to the moral order" (Goldburg, 1999: 173), although it could also refer more broadly to any unmarried pregnant women. Nonetheless, designated chambers for pregnant women are documented at St John, Oxford (Oxfordshire), and St Thomas, Southwark (London), and a small hospital at Blythe (Nottinghamshire), was re-founded in A.D. 1446 to shelter pregnant women (Orme, 2001).

Specific care of children or spaces for them in hospitals are rarely referenced in historical documents or suggested during archaeological investigations. Exceptions to this include St Bartholomew, London, which maintained orphaned or abandoned children until seven years of age (Rawcliffe, 1984; Orme and Webster, 1995). St James, Westminster, was established for "leprous girls or virgins and no others" (Gilchrist, 1995: 17). Although no ages are given, the founding statement implies this hospital housed juvenile or adolescent girls and young women. Historical records relating to St Leonard's, York, documented the presence of 18 children in A.D. 1287 and visitation documents from A.D. 1364 indicate boys and girls, possibly young orphans, were being cared for by the sisters (Cullum, 1991). Additionally, St Mary Spital, London, held a responsibility for the care of pregnant women, and destitute women and their children (White, 2007). Thomas *et al.* (1997) propose that an extension of the hospital in A.D. 1320-1350, was potentially a space created for mothers and young children.

2.2.3 Hospital Admission and Daily Life

Dyer (2012a) estimates that on average, 600 medieval hospitals could have housed 7,000 inmates. Consequently, only a minority of the poor and those in need of a hospital bed could be admitted, and thus, admission criteria were developed to determine who could enter. As Orme and Webster (1995) argue, however, rules illustrate the wishes of legislators, and not what necessarily happened in practice. Potential inmates of general hospitals such as St Mary's, Newark (Nottinghamshire), or St Bartholomew's, London, were examined at the gates, and then required to confess and say prayers for the hospital patron before entry was permitted (Carlin, 1989; Orme and Webster, 1995). Leprosaria were likewise selective. Places were often prioritised for the nominees of founders and those who could afford to pay for entry fees and lodging, whilst the poor resorted to begging for alms to secure a bed (Rawcliffe, 2006). Accounts exist for ceremonial religious vows taken by men and women entering leprosaria in Europe, although Rawcliffe (2006) states few similar documents survive for English hospitals. Whether children undertook the same form of ceremony is unknown.

On entry, inmates were required to relinquish their possessions into the care of the hospital. The identification of keys at St Bartholomew, Bristol (Avon), and St Mary Spital, London, suggest lockers were used to secure temporary inmates' belongings, although longer term inmates renounced all property including any potential inheritance (Thomas *et al*., 1997; Price and Ponsford, 1998; Rawcliffe, 2006). Inmates were given a uniform, frequently a quasi-monastic habit of a certain style or colour (Carlin, 1989; Rawcliffe, 2006). This was a means of identifying inmates as members of a particular hospital, and created a visual hierarchy within hospitals, distinguishing inmates from ecclesiastical and lay staff (Orme and Webster, 1995). Inmates typically received a bed, an adequate diet, clothing, and a clean and warm environment: conditions which enabled recovery from many common illnesses (Carlin, 1989; Rubin, 1989).

Daily hospital life was regulated according to monastic principles (Gilchrist, 1995; Rawcliffe, 2006). The rule of the leprosarium, St Mary Magdalene, Gloucester (Gloucestershire), stated inmates must observe the disciplines of obedience, patience, and charity, attend matins at dawn and other services through the day (Orme and Webster, 1995). If inmates did not abide by the rule, beatings or penances could be imposed (*ibid.*). Hospitals in Cornwall and Essex expelled inmates for breaches of hospital rules or disagreements with benefactors (Rawcliffe, 2006). Dyer (1989) suggests suspicions about the idleness and morality of the poor prompted strict hospital discipline. In addition to religious observations, inmates worked to occupy their time and enable the hospital to function. Duties included gardening, housework, laundry, and praying for benefactors (Orme and Webster, 1995). The occupations of children are not recorded, although possibly, akin, to family home life, they first imitated in play and then assisted adults with their duties. Hospitals in Exeter, Bristol, London, and York housed poor scholars, who in return, performed liturgical duties and sang in choirs (*ibid*.). Therefore, other children housed in hospitals possibly conducted similar duties. Diet was commonly regulated, with fixed quantities of bread, ale, and pottage allocated to inmates, and meat permitted on certain weekdays and feast days (Orme and Webster, 1995; Rawcliffe, 2006), although provisions varied between institutions. At a leprosarium in Maldon (Essex), inmates were given 'unsound' bread and ale, as it was believed lepers could digest rotting food without consequence (Roffey, 2012). At St Mary Magdalen, Winchester (Hampshire), lepers were given five pence each per week to spend on their food (*ibid*.). To contextualise this sum of money, an agricultural workers estimated average daily wage was £1.26 during the 13th century (Clark, 2007).

The medieval Church taught that illness was a physical manifestation of sin or "spiritual deformity" (Rawcliffe, 2006: 48). Care for inmates was therefore focused around their religious and spiritual wellbeing (Carlin, 1989). Participation in daily rounds of worship and the eucharist was deemed essential for spiritual healing (Carlin, 1989; Gilchrist, 1995; Orme and Webster, 1995). Carlin (1989) argues that typically, no medical care was offered in leprosaria or almshouses, and was limited in institutions founded for the sick poor, although Horden (2001) proposes that religion itself can be perceived as medicinal, and it is our modern conceptions of medicine which deem doctors and active treatment a necessity. Nevertheless, physicians are not regularly documented amongst hospital staff until the 16th century, and even then, only in larger London hospitals (Resl, 2008), although, in A.D. 1479, £5 was bequest to a surgeon to attend to the sick poor in London hospitals, illustrating their occasional presence (Thomas *et al*., 1997). Possible medical provisions in hospitals are discussed in Chapter 5 of this thesis. However, it is noteworthy that archaeological excavations and archaeobotanical analysis at St Mary Spital, London (Harward *et al*, 2019), St Mary, Ospringe (Kent) (Smith, 1979), and St Giles, Brough (North Yorkshire) (Cardwell, 1996), have identified medicinal plants, and ceramic and glass vessels which were potentially used in the preparations of medicinal tinctures and ointments. At St Mary Spital, evidence for a pharmacy was identified adjacent to the canon's infirmary (Harward *et al*., 2019). The location of the pharmacy could suggest treatments were reserved for the canons, yet these finds raise the possibility that medical care was administered to inmates.

2.2.4 Hospital Cemeteries

Hospitals were obliged to fulfil the seventh Comfortable Act, and bury those who died in their care, yet not all hospitals were founded with their own cemetery (Gilchrist and Sloane, 2005; Rawcliffe, 2006). The third Lateran Council of A.D. 1179 stated that all leprosaria should have their own chapel and cemetery (Rawcliffe, 2006). The dating of cemeteries is problematic as they are often first referred to, not in foundation charters, but separate legal documents. The cemetery of St James and St Mary Magdalen, Chichester, is first documented decades after the hospital's foundation in A.D. 1118, in a legal dispute referring to burials previously conducted at the hospital, suggesting the cemetery was already well established (Magilton *et al*., 2008). St Bartholomew's, Newbury (Berkshire), is first documented in A.D. 1215, yet a licence for burial was not issued until 1267 (Clough and Witkin, 2006). Clough and Witkin (2006) suggest, the granting of a licence may have been a formality, approving a practice already in existence, although it is possible hospital inmates who died during the first 50 years of the hospital's foundation were buried in the parish cemetery.

Medieval cemeteries can be difficult to date or phase archaeologically, due to the typical lack of dateable objects found in association with burials. However, pottery and lace tags were identified in burials at St Leonards hospital, Peterborough which enabled the excavators to prescribe dates to certain areas of the cemetery (McComish *et al*., 2017). Stratigraphic sequencing of burials and interpretations of cemetery developments were also used at St Mary Spital, London, and St James and St Mary Magdalene, Chichester, to chronologically phase the use of these cemeteries (Magilton *et al*., 2008; Connell *et al*., 2012). At these sites, and at St John, Cambridge (Cessford, 2015), radiocarbon dating of human skeletal remains was conducted, which supported the sequencing of the phases and permitted calendar dates to be assigned to each phase. This information can aid interpretations of the changes in the use of cemeteries or burial practices. In addition, changes in the age, sex, and health status of those interred in the cemetery, can further indicate developments in the hospitals themselves over time (Magilton *et al*., 2008).

The regulations on who could be accepted into a hospital population, can indicate the likelihood of the presence of children, and this could arguably, be related to the demographics identified in a hospital's cemetery. However, there are inherent problems in making assumptions about a hospital's population based on hospital rules or cemetery demographics. Firstly, the rules established by founders were not always followed and could be altered over time (Rawcliffe, 1984). Secondly, hospitals buried not only hospital inmates, but also founders, masters, staff, and their dependents (Harding, 1992; Gilchrist, 1995; Sweetinburgh, 2004; Goacher *et al*., 2016). Furthermore, the local parochial community were possibly buried within hospital cemeteries at times of pressure on parish cemeteries. For example, Connell *et al*. (2012) suggest the cemetery of St Mary Spital, London, was used to bury victims of famines during the early 14th century. Therefore, although it is probable that non-adults identified archaeologically at hospital sites were inmates, it cannot be said with certainty that the individuals considered in this thesis were hospital residents when they died.

2.2.5 Summary

This survey of the English medieval hospital has highlighted the diverse, complex nature and life cycles of these institutions. The Church taught the importance of the wealthy providing charity for the poor to atone for sin, and therefore while many hospitals were founded by monasteries, lay persons also founded hospitals or became benefactors (Gilchrist, 1995; Orme and Webster, 1995). Entry into a hospital was restricted: benefactors could allocate beds to certain favoured individuals, and examinations of the health and piety of those seeking a hospital bed were conducted in line with hospital regulations (Rawcliffe, 2006). Hospitals were typically run along monastic principles, with religious observance an important aspect of daily life (Gilchrist, 1995; Orme and Webster, 1995). Inmates gained a bed, food, and the care of hospital staff, in return for which, if able, they participated in work duties (Rawcliffe, 2006). Many inmates were short term residents who left a hospital once capable. For inmates who died within a hospital, the institution fulfilled their obligation to bury them, either in a parish burial ground or increasingly from the

12th century, within the hospital's own cemetery (Gilchrist and Sloane, 2005; Rawcliffe, 2006). The section below moves on to focus on developments within the history and archaeological disciplines, to consider how children in the past are observed and understood today, and how they were defined within the medieval period.

2.3 The Medieval Child

Following work by Aries (1962), which disputed that 'childhood' existed in the medieval period, discussions have ensued about children in the past and their place within medieval society. From the 1970s onwards, Aries theory was refuted by numerous scholars who have drawn on various sources of evidence to examine the role of children and childhood in the medieval period (De Mause, 1974; Hanawalt, 1977; Crawford and Lewis, 2009; Crawford et al., 2018b). Historical documents including coroner's rolls, miracle stories, court records, and educational accounts, have been used to explore the daily activities of children, their environments, and adult behaviour towards children (Hanawalt, 1977, 2002; Gordon, 1991; Orme, 1994, 2001, 2006, 2012; Finucane, 1997). Bioarchaeological studies continue to enhance our understanding of factors influencing childhood health, such as social and economic status, the physical environment, and working practices (Dawson, 2014; Penny-Mason and Gowland, 2014; Lewis, 2016). Theoretical developments within the wider archaeological discourse are considered below. This section then concludes with a reflection on medieval concepts of childhood and the biological and behavioural phases which marked the stages of life, from birth through to the beginnings of adulthood.

2.3.1 Children in the Archaeological Discourse

Bluebond-Langner and Korbin (2007) argue that the creation of the United Nations Convention on the Rights of the Child (UNCRC) in 1990 was a pivotal event in scholarship, stimulating research which considered the views and perspectives of children. Only a year earlier, Lillehammer's (1989) pioneering paper, highlighted the lack of consideration for children within the archaeological discourse, calling for an awareness of the materiality of childhood and the importance of understanding the child's world. Drawing on ethnographic work, Lillehammer (1989) illustrated the diversity of childhood in differing cultures, observing the influence of societal systems on determining the behaviour of children and the culturally determined duration of childhood. Kamp (2001) further argues that studying and understanding children in the past is essential to fully comprehend social structures, economies, and belief systems. As childhood is the primary formative stage in the human life span, the experiences of childhood will shape the lives of adults and therefore adult society (Lillehammer, 1989; Crawford and Lewis, 2009). Yet, as Crawford and Lewis (2009: 6) argue, children themselves leave few enduring records or material objects, making them "difficult to detect and therefore so easy to ignore".

Halcrow and Tayles (2008) argue that difficulties in the study of past populations arise due to assumptions made about past societies based on modern Western ideals of 'childhood'. Baxter (2008) agrees that these assumptions result in archaeologists considering children in terms of their dependant relationships with adults and viewing them as innocent and vulnerable. Yet, this approach is changing, partly in relation to the developing theories in social identity, gender, and feminism which consider identities as actively created and practised, and individuals as having active agency (Baxter, 2008). However, Bluebond-Langner and Korbin (2007: 244) state, there continues to be a reluctance to recognise the agency of children when they participated in "morally wrong" activities, for example, their engagement in crime or war.

Over the past 20 years, the importance of studying children and childhood has gained momentum. This is evidenced by the number of journal articles and edited volumes dedicated to the subject, and the foundation in 2007 of the Society for the Study of Childhood in the Past (Crawford and Lewis, 2009; Hadley and Hemer, 2014). Themes which have emerged in the archaeological study of children and childhood include the material culture of children, play, stages of childhood, the social value, identity, and status of children, social interactions, education and mechanisms of knowledge transfer, and funerary practices and the burial of children (Sofaer Derevenski, 2000; Baxter, 2006; Crawford and Shepherd, 2007; Dommasnes and Wrigglesworth, 2008; Lally and Moore, 2011; Crawford *et al*., 2018a). Yet many scholars' works focuses on the prehistoric, classical, or post-medieval periods. Hadley and Hemer's (2014) edited volume '*Medieval Childhoods'*, highlights the importance and diversity of research and analysis on medieval children and their daily life, play, work, and death and burial. In 2015, Kamp put forth the argument that an archaeology of childhood had still not matured, and the child continued to be at the periphery of cultural discourse for many archaeologists. Yet, Crawford *et al*. (2018b: 11) argue, their volume *The Oxford Handbook of the Archaeology of Childhood*, demonstrates that now “there is no archaeology without children”. Whilst Kamp (2015) rightly argues there is scope for advancing the theoretical and methodological archaeological approaches to recognise the complexities of children and childhoods, the above overview illustrates substantive advances in the archaeological discourse in the 30 years since Lillehammer (1989) first called for archaeologists to recognise children and the child’s world in the past.

2.3.2 Defining the Medieval Child

In the archaeological and anthropological disciplines, an individual’s age is categorised in three ways: chronologically, measured by the time passed since birth; biologically, determined by physical changes in the body (see Chapter 3); and socially, through an understanding of the culturally assigned age given to individuals in relation to different behavioural stages in life (Lewis, 2007; Halcrow and Tayles, 2008; Gowland and Penny-Mason, 2018).

The Ages of Man was a system employed during the medieval period to characterise age groups (Shahar, 1990; Orme, 2001; Gilchrist, 2012; Dawson, 2014; Oosterwijk, 2018). In effect, this system combined chronological ages, with biological determinants such as tooth development, and culturally determined behaviours to categorise various stages of life. Prior to adulthood these categories were: *infantia* (birth to seven years of age), *pueritia* (seven to 12 years of age for girls and 14 years of age for boys), and a*dolescentia* (12 or 14 for girls and boys respectively to 21 years of age) (Shahar, 1990; Oosterwijk, 2018). The stage of *infantia* can be subdivided into two phases: the first defined by a child’s lack of speech and teeth, which ends at approximately two years of age when primary dentition emerge and a child can be weaned (Shahar, 1990). The second phase begins when a child becomes mobile and develops speech (Dawson, 2014). During *infantia* a child was considered vulnerable and fragile, and Shahar (1990) states that parents or guardians were encouraged by contemporary writers and the clergy to nurture and care for their children. *Pueritia*, beginning at seven years of age, was associated with the emergence of the permanent teeth, the development of articulate speech, and the ability of a child to express themselves (Shahar, 1990; Gilchrist, 2012). Children were thought of as pure at this age yet capable of sin as they could distinguish right from wrong and were competent of choosing between them (Shahar, 1990). At this life stage, boys could enter the Church, schooling and apprenticeships began, and whilst not binding after the mid-12th century, children could be betrothed (Shahar, 1990; Dawson, 2014).

The onset of puberty was related to the start of *adolescentia* when children increasingly gained independence. Their understanding of the world was deemed to have developed sufficiently for them to participate in religious sacraments, partaking of the eucharist and attending confession (Shahar, 1990). Shahar (1990) states the end of *adolescentia*, unlike the previous life stages, was fluid. Economic independence and marriage were two important factors which signified adulthood (Shahar 1990). The law used different ages of majority at which young people were held fully responsible for their actions and could acquire the right to administer their own affairs (Orme, 2001). Through *adolescentia*, young people were held criminally responsible in civil courts (*ibid*.). However, their age, the nature of the crime and the intent of the offender influenced whether they received a partial or full normative adult punishment, suggesting adolescents were not deemed fully responsible for their actions (Shahar, 1990; Orme, 2001; Bailey *et al*., 2008). The medieval writer and philosopher Dante (c. A.D. 1265-1321) believed a man was not intellectually developed and could not make rational judgements until 25 years of age (Shahar, 1990). This was also the age at which many apprenticeships ended, and the apprentice was considered an independent adult (Lewis, 2016). The writings of the scholar Isidore of Seville (A.D. 560-636) were influential throughout the medieval period, and he considered maturity was not reached until 28 years of age (Shahar, 1990).

2.3.3 Summary

This section has reviewed approaches to the study of children and childhood in the past within the disciplines of history and archaeology. It is now accepted that childhood is a fluid concept, differing between cultures and influenced by societal structures (Lillehammer, 1989). Children have become increasingly embedded within the archaeological discourse, and methodological approaches to identifying objects and spaces which may have been used by children are emerging (Lewis, 2009; Harper, 2018). Bioarchaeological studies are creating new insights into the health status of English medieval non-adults, from which inferences can be made into their activities, their social status, and differential treatment of children (Dawson, 2014; Lewis, 2016). Whilst scope remains for greater consideration of children and their actions in the past (Orme, 2009; Kamp, 2015), this review has illustrated the theoretical and methodological advances which have occurred over the past 30 years. This section concluded with a reflection on how children were perceived during the medieval period. Life stages as documented in the medieval system of the Ages of Man, were shown to incorporate both biological and behavioural developments. The concepts and practices of determining age from skeletal remains, the influences on skeletal development, and the advances and limitations in identifying disease, trauma, and general stress indicators on the non-adult skeleton, are the foci of the next section.

Chapter 3. Bioarchaeology: Theoretical and Methodological Approaches

Bioarchaeological approaches can increase our knowledge of historical populations, providing a unique “perspective on humans as both biological and cultural beings” (Martin and Harrod, 2012: 31). Advances in bioarchaeological theories and methods have enabled researchers to make inferences about the wider social realm (Knudson and Stojanowski, 2008). For instance, this section begins with a review of theoretical approaches to understanding intergenerational influences on health, individual care needs, and provision of care. There are, however, difficulties within bioarchaeology which can prevent broad statements about past populations being made (Perry, 2007). Advances and limitations in understanding cemetery demographics and determining non-adult age at death are discussed below. This is followed by examples of disease and trauma which illustrate the possibilities and difficulties of inferring health status from skeletal remains. Finally, consideration is given to the theoretical and practical means of interpreting skeletal indicators of episodes of general stress.

3.1 Theoretical Models

In addition to the life course approach (see Section 2.1), two further theoretical models are employed in this thesis. Firstly, the Developmental Origins of Health and Disease (DOHaD) hypothesis which states that foetal experiences in the womb and early childhood environments are intricately linked with susceptibility to disease during life (Barker and Osmond, 1986; Barker, 1990). The hypothesis has been tested by numerous studies which support the theory that *in utero* deprivation, caused by poor maternal health, associated with the mother’s own impoverished childhood, results in higher risks of stillbirth, neonatal mortality, and disease in later life (Barker, 2007; Armelagos *et al*., 2009; Weisensee, 2013; Fleming *et al*, 2015; Godfrey *et al*., 2015; Gowland, 2015). Newman and Gowland (2017) conducted a nuanced study of socio-economic status on the health of non-adults from four 18th-19th century cemetery sites in London. Whilst pathologies such as rickets and dental enamel hypoplasia were identified on individuals from each cemetery, higher rates of perinatal death and pathology, and lower growth values, were observed on non-adults from the lower-class areas of the city (Newman and Gowland, 2017). From this it was inferred that the effects of poverty, including dietary deficiencies, harsh environments, and child-care practices, had inter-generational consequences on the health of individuals and wider communities (*ibid*.).

Secondly, Tilley's (2015) 'Bioarchaeology of Care' model is the basis for discussions around health care provision in Chapter 6. Dettwyler (1991) argues that care and compassion in past societies cannot be determined through archaeological and osteological practices. Dettwyler (1991: 375) cites instances of bias by archaeologists who, arguably, confused disability with nonproductivity and sought to frame past peoples as morally compassionate and caring "noble savages". Care was largely unexplored within archaeology, yet Tilley and Cameron (2014) developed a clinically based Index of Care, which overcame many of Dettwyler's concerns and provided a systematic means of questioning levels of care required and given in the past. A four stage 'Bioarchaeology of Care' model was proposed by Tilley (2015) to interpret the care required by an individual. Firstly, evidence of disease or disability is identified from skeletal remains, followed by the inference of any functional impacts. Evidence for healthcare provision is explored by considering the duration of care required, and finally, the ability of the contemporary society to deliver the necessary care is discerned (Tilley, 2015). This approach is valuable in negotiating interpretations of health and care giving in the past, although limited by its focus on the individual. The framework is now being expanded (see Schrenk and Tremblay, 2022) to encompass care provisions at a population-based community level. Penny-Mason (2022) utilises this broader approach and the life course perspective to explore the care of medieval people with tuberculosis, illustrating the difference in need and provision of care for independent adults and younger dependent children.

3.2 Medieval Cemetery Demographics

The evaluation of medieval cemetery demographics has some inherent difficulties due to the differing burial practices of past populations, and modern-day archaeological practices and assumptions (see Hookway and Squires, 2020). As Jackes (2011) argues, a cemetery population is representative of the dead, not the living. Inferences can be made about past populations, yet a cemetery has a life cycle, and its population cannot necessarily be analysed as a single cohort (Jackes, 2011). Primary burials were occasionally disturbed through the repeated use of medieval cemeteries and the insertion of secondary burials. This is evidenced by the intercutting of graves and disarticulated skeletal remains observed from many sites considered in this thesis, for example at St Bartholomew, Newbury (Clough and Witkin, 2006), and St Leonard's, Peterborough (Cambridgeshire) (McComish *et al*., 2017).

Non-adults, in particular infants, are often under-represented in medieval cemetery contexts due to multiple factors (Lewis, 2007; Mays, 2010a; Dawson, 2014). Cultural burial practices influence the location of child burials, for example, the zoning of infant burials occurred at St Mary Spital, London (Connell *et al.,* 2012), and St James and St Mary Magdalene, Chichester (Magilton *et al*., 2008). Manifold (2015) studied burial practices at six English medieval cemeteries and found children were typically buried in shallower graves than adults, making them more prone to taphonomic processes. Children's bodies typically decay faster than an adult's, are more easily disarticulated, and are at a greater risk of dispersal due to animal scavenging behaviour (Lewis, 2007). Furthermore, non-adult bones are less dense and more porous than those of adults and are consequently more susceptible to deterioration (Gordon and Buikstra, 1981; Mays, 2010a). Yet, when environmental conditions favour good skeletal preservation, the preservation of non-adult skeletal remains is similar to that of adults (Buckberry, 2000; Mays, 2010a; Dawson, 2014). In such instances, archaeological methods and practices of identifying and excavating small bones are important factors in recovering non-adult skeletal remains (Mays, 2010a).

Historic England's guidelines on the reporting of human bone from archaeological contexts, advise that disarticulated remains from medieval period sites are a lower priority than articulated skeletons and are "not usually considered worthy of study at the analysis phase" (Mays *et al*., 2018: 17). McIntyre and Hadley (2012) argue however, that disarticulated skeletal remains are valuable and should be included in the analysis of cemetery populations. Of the 28 non-adults under 14 years of age, from the hospital of St Mary Magdalene, Bawtry (South Yorkshire), 19 (67.9%) were identified within the disarticulated assemblage. Consequently, non-adults would have been under-represented at this site if the disarticulated remains had not been included in the demographic analysis (McIntyre and Hadley, 2012). Similarly, as Henderson and Knight (2013) report, non-adults formed 16.4% of the articulated population from St Peter, St Paul, and Thomas the Martyr, Maidstone (Kent), although 25.1% when preliminary analysis on disarticulated remains from the site are considered.

A further assumption regarding cemetery populations is the locale in which those interred lived or originated from. Dyer (2012a) argues that the location of most hospitals in urban areas, made it difficult for the rural poor to access them, thus implying, that hospitals served a local community. Yet, whilst this may be applicable to many institutions, analysis of skeletal populations from hospital cemeteries conducted in the last decade, is revealing new insights into hospital communities. Cranial analysis of four individuals from St John, Lichfield (Staffordshire), suggests these individuals were of African origin (Loeffeimann and Hoist, 2016). The hospital of St John was founded to house pilgrims to the shrine of St Chad in Lichfield Cathedral (Goacher *et al*., 2016; Styler, 2020). It is therefore conceivable that these individuals were undertaking pilgrimage when they died. Additionally, a study by Filipek *et al*. (2022) analysed strontium and oxygen isotopes of 19 adolescents from the cemetery of the leprosarium, St Mary Magdalen, Winchester. The results indicate 12 adolescents were raised locally, whilst four were from the Winchester hinterland or potentially western Britain, and three were probably from Eastern Europe or the Mediterranean region (Filipek *et al*., 2022). Filipek *et al*. (2022) suggest people travelled to Winchester after contracting leprosy, possibly seeking treatment at this hospital, which was one of the earliest leprosaria founded in England, and importantly, that care was extended to them.

3.3 Osteological Methods of Ageing Non-adults

Determining an accurate age at death for non-adults is an important element of osteological analysis when inferring child health and mortality rates, cultural practices related to childcare, nutrition and feeding practices, and environmental conditions (Lewis, 2007). As secondary osteological data are used in this thesis, the accuracy of age estimates will vary between the reports utilised, depending on the ageing methods available to, and used by, the osteologist. Studies into ageing skeletal remains have evolved over decades and since the latter 20^{th} century, research has produced more sophisticated methods of estimating age (see Ubelaker and Khosrowshahi, 2019). Advances include the identification of the stages of development of individual bone elements, and the recognition of the influences of socio-economic and environmental factors on skeletal and dental development (see Cunningham *et al*. 2016). Biological age is assessed using tooth and skeletal developments identified through macroscopic observations, radiography, and histological techniques (Gowland and Thompson, 2013). Tooth formation begins around 15 weeks gestation and ends with the final eruption of the third molar around 17 years of age, with development and eruption of deciduous and permanent teeth occurring at known stages (within margins of error) in-between (Lewis, 2007; Scheuer and Black, 2004). Skeletal developments used to calculate age include long bone growth, the appearance of ossification centres, and the fusion of the epiphyses (Scheuer and Black, 2004).

Teeth are the preferred method of ageing a non-adult due to their more predictable development and typically, they have better preservation rates than bone within archaeological contexts (Scheuer and Black, 2000, 2004; Lewis, 2007; Gowland and Thompson, 2013). During infancy, tooth development can determine age to within a few weeks, although estimates become more imprecise as a child grows, with the margin of error increasing to two-three years during adolescence (Mays and Anderson, 1995). Bone development is more susceptible than teeth to disruption caused by environmental factors such as disease and malnutrition, and the relationship between age and bone length decreases as age increases (Scheuer and Black, 2000, 2004; Lewis, 2007). Yet, Gowland and Thompson (2013) argue long bone growth is more advantageous in determining the age of foetal and perinatal skeletal remains due to rapid growth at this particular stage.

Disruption to skeletal growth can be caused by multiple factors, including maternal health during pregnancy and the post-natal experiences of a child (Hodson, 2021). Poor levels of nutritional intake can result in delayed long bone growth and may reflect problems around weaning or periods of malnutrition (Huss-Ashmore *et al*., 1982). Holman and Yamaguchi's (2005) study of early 20th century Japanese children, identified delayed emergence of deciduous teeth in 14-29% of children who were not breastfed or experienced under-nutrition, compared to children with a moderate nutritional intake. Exposure to infectious disease can also result in growth disruption or prolonged skeletal growth, particularly if these events occur during infancy (Humphrey, 2000). Relatively short episodes of stress, which hinder skeletal growth can be compensated for when a child returns to health, although prolonged periods of stress can cause a permanent disruption to growth (Lewis, 2007).

Once biological age is established, it is often correlated to a chronological age using established dental development standards and regression analysis (for various standards see Lewis, 2007; Gowland and Thompson, 2013). Liversidge *et al*. (2010) compared different dental development standards to establish their accuracy when determining chronological age, finding many methods resulted in an age bias of 0.86-1.03 years. Their study found that most methods of analysis over-estimated the age of younger children whilst under-aging adolescents, however radiographs of the teeth of modern-day children were used, and consequently variations in the chronological ages determined from dental development may be influenced by differences in environmental or dietary factors (Liversidge *et al*., 2010). Additionally, tooth development is on average more advanced in females than males by between one to six months (Lewis, 2007). Due to these limitations in estimating chronological age, Roksandic and Armstrong (2011) argue that bioarchaeologists should avoid using chronological ages. They advocate the use of a life history model in which established stages of dental and skeletal development correspond with a particular life stage (Roksandic and Armstrong, 2011).

However, differing criteria and terminology to categorise stages of life prior to adulthood are used across and within different disciplines (Table 3.3.1) (Halcrow and Tayles, 2008; Hookway and Squires, 2020). This can cause confusion and hinder inter-disciplinary understanding and research into non-adults (Crawford and Lewis, 2009). For example, the clinical definition of an ‘infant’ is an individual under one year of age, although the term is also used to define non-adults up to five years of age, which, Lewis (2007) argues, ignores important physiological and social developments during these years. Similarly, the British legal definition of ‘juvenile’ is a person under 18 years of age, yet it is used in anthropology and bioarchaeology to describe specific sub-categories of non-adult age (Halcrow and Tayles, 2008; Woodley, 2013). Although there is no single accepted model of terminology, such debates demonstrate the importance of integrating biological developments and socio-cultural behaviours and attributes of children within childhood studies.

Table 3.3.1 Terminology and categorisation of non-adult life stages used in different disciplines.

Life Model stages proposed by Roksandic and Armstrong (2011: 341)		
Life Stage	**Biological Markers**	**Associated Chronological Age**
Infancy	Ends with full deciduous dentition.	-
Early Childhood	Ends with eruption of first permanent tooth.	-
Late Childhood	Ends with eruption of permanent canine.	-
Adolescence	Ends with epiphyseal fusion of long bones.	-

British Bioarchaeology (Lewis, 2007: 2)		
Life Stage	**Biological Markers**	**Associated Chronological Age**
Neonatal	-	Birth-27 postnatal days
Post-neonatal	-	28-346 days
Infant	-	Birth-1 year
Child	-	1-14.6 years
Adolescent	-	14.6-17 years

European Bioarchaeology (Scheuer and Black, 2004: 7)		
Life Stage	**Biological Markers**	**Associated Chronological Age**
Infans I	Ends with eruption of first permanent molar.	0-7 years
Infans II	Ends with eruption of second permanent molar.	7-14 years
Juvenile	Ends with closure of the spheno-occipital synchondrosis.	15-22 years

Evolutionary Anthropology (Bogin and Smith, 2000: 521)		
Life Stage	**Biological Markers**	**Associated Chronological Age**
Neonatal	Rapid growth rate.	Birth-28 days
Infancy	Deciduous tooth eruption.	Second month-c. 36 months
Childhood	Eruption of first permanent molar and incisor.	3-6.9 years
Juvenile	Slower growth rate. Ends with the onset of puberty.	7-10 years (girls), 7-12 years (boys)
Adolescent	Permanent tooth eruption almost complete.	5-10 years after the onset of puberty

3.4 Identifying Disease and Trauma

Today, the predominant causes of death in under five-year-olds globally are infectious diseases including lower respiratory infections, acute respiratory infections, diarrhoea, and malaria (World Health Organization, 2017; Besnier *et al*., 2019). These diseases pose a significant mortality risk to non-adults, particularly those in low-income countries where poverty and a lack of access to modern health care and medicines inhibit infection control (Roberts and Manchester, 2010; Besnier *et al*., 2019). It is likely that similar infections also caused high levels of mortality in the medieval period (Dawson, 2014). However, acute infections can result in rapid death, before any modification of the skeleton occurs and, consequently, are not observable on skeletal remains (Roberts and Manchester, 2010).

Chronic conditions which can cause infirmity and disability are also not always visible on the skeletal remains of those who lived with the condition. Leprosy is associated with poverty, a poor diet, and overcrowding in high density population centres (Roberts, 2011). The disease can have a lengthy incubation period, and an individual's response to infection varies, dependent on their own immunity status (Roberts and Manchester, 2010). The skeletal evidence diagnostic of leprosy are inflammatory changes, and bone destruction and remodelling, importantly, distributed on the maxilla, the tibia and fibula, and the phalanges, metatarsals, and metacarpals (Manchester, 2002; Ortner, 2002). Yet, typically, only 3-5% of people with leprosy develop skeletal changes (Roberts, 2011). Consequently, more non-adults in the medieval period had leprosy than can be skeletally identified. However, advances in histological analysis are increasing the accuracy of identification of the disease (Schultz and Roberts, 2002). Additionally, aDNA analysis of medieval skeletal remains is corroborating osteological observations and furthering the genotyping of strains of leprosy, creating a more detailed understanding of the spread of leprosy across the world (Taylor *et al*., 2013).

Rickets is caused by a deficiency in vitamin D which is needed for the body to absorb calcium (Roberts and Manchester, 2010). The deficiency is primarily due to a lack of exposure to sunlight although dietary factors or an individual's inability to absorb vitamin D are additional causative factors (Ortner and Mays, 1998). Vitamin D deficiency rickets manifests on the skeleton as porous lesions on the cranial vault, orbital roofs, and long bones, and as deformity or bowing of the long bones (Brickley *et al*., 2020) although, the lesions caused by rickets can heal and be fully remodelled in older individuals (Ortner and Mays, 1998). Snoddy *et al*. (2016) argue skeletal indicators of rickets are indicative of a spectrum of negative health outcomes associated with vitamin D deficiency and should be considered in the context of other nutritional deficiencies and comorbidities. Research in palaeopathology often focuses on the diagnostic criteria for individual pathologies, yet Brickley *et al*. (2020) highlight the need for studies to recognise and develop a greater understanding of the co-occurrence of disease and the potentially complex consequences of multiple diseases on a person's health status.

Trauma, defined as "any bodily injury or wound" (Roberts and Manchester, 2010: 84) is evidenced on the skeleton by a partial or complete break in the bone, an abnormal displacement of a bone, or an artificially induced abnormal shaping of the bone (Ortner, 2003; Roberts and Manchester, 2010). Identifying fractures in non-adult skeletal remains is complex due to the plasticity of non-adult bone and the obliteration of fractures by the normal growth and development of bone (Ortner, 2003; Lewis, 2007; Verlinden and Lewis, 2015). Factors such as low bone mass, small bone size, and skeletal fragility can increase a non-adult's risk of sustaining a fracture (Clark *et al*., 2006; Clark *et al*., 2009; Forestier-Zhang and Bishop, 2016). These factors can be genetic in origin (Bulloch *et al*., 2000), or caused by chronic inflammatory diseases (Burnham, 2012), and metabolic diseases such as rickets (Charoenngam *et al*., 2020). Thus, observations of pathology are also important in understanding an individual's risk of sustaining trauma.

3.5 Interpreting General Stress Indicators

Stress is defined by Selye (1956: 55) as "the non-specific response of the body to any demand". Edinborough and Rando (2020) criticise the use of the term 'stress' in bioarchaeology, arguing the term has become too vague and should be limited to precise qualifications such as 'mechanical stress'. However, it is Selye's definition which is applied within this thesis, as social and environmental factors which can increase demands on the body are considered, in addition to mechanical stressors. Three skeletal markers used in bioarchaeology to indicate periods of physical stress are cribra orbitalia, periosteal reaction, and dental enamel hypoplasia (Ribot and Roberts, 1996; Boldsen, 2007; DeWitte, 2014; Dawson-Hobbis, 2017). These markers can develop due to genetic factors, immune status, or the direct experience by a child of malnutrition, illness, or trauma (Lewis, 2007; Roberts and Manchester, 2010). The presence of stress indicators can be used to explore inter-generational life experiences, as stresses experienced by a pregnant woman can affect the health of the foetus and subsequent development of the child (Gowland, 2015). Additionally, early stress experiences can have a detrimental effect on a child's ability to survive further episodes of disease or stress (Lewis, 2007). However, interpretation of the presence of general stress indicators on skeletal remains is complex due to the ‘osteological paradox’.

The osteological paradox, developed by Wood *et al*. (1992) asserts that individuals exhibiting stress indicators represent those with a strong immune response, able to survive episodes of infection or environmental stress. Conversely, individuals without skeletal modifications had greater individual frailty, and were unable to survive periods of stress (Wood *et al*. 1992). DeWitte’s (2014) study of skeletal remains from medieval London arguably supports this paradox, as it was found that individuals with healed subperiosteal new bone formation had a survival advantage over those with active lesions or with no lesions. A study by Bennike *et al*. (2005) compared stress markers from skeletal assemblages from a leprosarium and a monastic site in Denmark. Overall, greater levels of stress markers were identified in the cohort from the leprosarium, the population considered to be more disadvantaged. Although at both sites, individuals displaying stress indicators lived for longer than those without. Bennike *et al*. (2005) argue, these findings illustrate the complexities of interpreting health status and the importance of considering the cultural and economic contexts of populations.

Cribra orbitalia is characterised by porous orbital roof lesions and associated with porotic hyperostosis evidenced by similar lesions on the cranial vault (Lewis, 2007). The lesions are caused by an expansion of the bone marrow due to an increase in red blood cell production (*ibid*.). Cribra orbitalia is associated with iron-deficiency anaemia due to malnutrition or infection (Lewis, 2007; Oxenham and Cavill, 2010; Roberts and Manchester, 2010), although, the exact cause is disputed and Brickley (2018) argues that correlating features of anaemia or other causes need to be considered. Alternative aetiologies include megaloblastic anaemia caused by a co-deficiency of vitamin B_{12} and vitamin C from dietary sources, and nutritional loss from gastrointestinal infections (Walker *et al*., 2009). Studies have shown a higher level of mortality during the medieval period in individuals with cribra orbitalia compared to those without (Roberts and Manchester, 2010; Godde and Hens, 2021).

Subperiosteal new bone formation is the deposition of new bone on the outer surface of bone, caused by inflammation of the periosteum (Mays, 2010a). The same bone response is initiated by a range of specific and non-specific infections, neoplastic disease, and trauma (Weston, 2008). While an infection is active, new bone is laid down as woven bone, which is remodelled to lamellar bone as the lesion heals, indicating an individual survived the acute stage of disease or trauma (Roberts, 2000a; Mays, 2010a). The appearance of both woven and lamellar bone on skeletal remains is indicative of a chronic and re-occurring infection (Lewis, 2007). Identifying subperiosteal new bone formation in non-adults can be problematic as the pathological formation is similar to normal bone growth developments and lamellar bone can resemble normal compact bone (Lewis, 2007; Weston, 2008). Consequently, the prevalence of subperiosteal new bone formation may be underestimated in non-adult populations.

Dental enamel hypoplasia (DEH) develop during times of malnutrition or disease during childhood, when the deposition of dental enamel is disturbed, resulting in the development of bands or pits of depressed enamel on a tooth (Mays, 2010a). DEH can develop from *in utero* to around 12 years of age, although Reid and Dean (2000) propose that stress experienced within the first year of life is rarely evidenced as DEH. However, as enamel is not remodelled, the striations can be observed in adults, providing a record of childhood stress (Armelagos *et al*., 2009; Miszkiewicz, 2015). As dental development and age are closely associated, DEH can be used to identify the age at which an individual experienced stress (Lewis and Roberts, 1997; MacLellan, 2004). Additionally, DEH can imply differing cultural practices around weaning, preferential treatment of children by sex or social status, and mortality and longevity, at a cultural level (MacLellan, 2004; Armelagos, *et al*., 2009; Miszkiewicz, 2015; Dawson-Hobbis, 2017; Gamble *et al*., 2017).

3.6 Associations between Socio-Economic Status, Environments, and Pathologies

There are multiple factors which influence an individual's health status and impact their likelihood of developing certain pathologies or risk of sustaining trauma. Such factors include genetic heritability, a family's social and economic status, diet, the physical environments of home or work, and urban and rural locations, and the detrimental health impacts of co-occurring pathologies. The following exploration of these dynamics is presented within the themes of family, environments, work, and the co-occurrence of pathologies, mirroring the discussion in Chapter 6.

3.6.1 Family and Home Environments

Developmental abnormalities, or congenital conditions, commence during the foetal stage and can become apparent at, or shortly after, birth (Roberts and Manchester, 2010). There are multiple causes of congenital conditions, including the genetic composition of the foetus and external environmental influences on the mother (*ibid*.). Studies on the impact of social conditions on the development of congenital anomalies are scarce (Pawluk *et al*., 2014). A clinical study in Latin America by Pawluk *et al*. (2014) identified an association between lower socio-economic status and only two out of 25 congenital anomalies reported in new-borns, cleft palate and ventricular septal defect. Yet, in a study of 196 countries, Matin *et al*. (2020) found a correlation between poverty, congenital conditions, and mortality in under five-year-olds. This research identified higher rates of congenital conditions in younger juveniles from low-income countries, with high poverty rates, where typically access to health care and education are most limited (Matin *et al*., 2020).

As the DOHaD hypothesis asserts, the dietary intake of a pregnant women directly impacts the development of the foetus and subsequent health of the child. Modern-day clinical studies illustrate that poor maternal nutritional status, both before and during pregnancy and breastfeeding, increases the risks of babies being born with birth defects and low body weight, and creates a greater risk of chronic illness later in life (Sharma and Mishra, 2014; Thayer *et al*., 2020; Marshall *et al*., 2022). Studies of historical and modern populations have identified those most at risk of developing dental enamel hypoplasia are typically amongst the poorest in a society (MacLellan, 2004; Ford *et al*., 2009; Nakayama, 2016). Medieval children born into the lower-class would have been at a higher risk of health difficulties related to malnutrition as their mother's diets and their own, were unlikely to be adequate (Hanawalt, 1993). Yaussy *et al*. (2016) established a relationship between early life stressors and mortality in individuals buried in the multiple burials at St Mary Spital, London, which are thought to date to the period of famines in the early 14th century. Consequently, adolescents who experienced childhood malnutrition were more vulnerable than their peers to frailty or ill-health, which potentially contributed to their premature deaths (Connell *et al*., 2012).

Infants and younger juveniles are vulnerable to acute infections, especially during the weaning period when access to the nutrients and immunity provided by breastmilk is reduced (Hühne-Osterloh and Grupe, 1989; Katzenberg *et al*., 1996; Mays, 2010b). In the present day, pneumonia, diarrhoea, and malaria are leading causes of death in children under five years of age (WHO, 2020) and would have caused deaths in this age group during the medieval period (Redfern, 2012a; Stone, 2013). However, these infections are rarely observable in the archaeological record (Roberts and Manchester, 2010). Furthermore, subperiosteal new bone formation in younger juveniles can be mistaken for new bone developing as part of normal growth, making the identification of subperiosteal new bone formation problematic in younger age groups (Roberts, 2000a; Lewis, 2008; Dawson-Hobbis, 2017).

Both diet and parental practices can influence the development of certain pathologies, for example, Vitamin D deficiency rickets. Veselka *et al*. (2021) found that infants who were breastfed for a shorter duration and weaned earlier than their contemporaries were more likely to develop rickets. A limited number of foods, including cod-liver oil, oily fish, beef liver, and egg yolk do contain small amounts of vitamin D (Brickley *et al*., 2020). The exclusion of these foodstuffs or calcium rich foods from weaning diets can influence an infant's level of vitamin D and may contribute to the development of rickets (Brickley *et al*., 2020; Veselka *et al*., 2021). Most of the vitamin D acquired by humans, however, comes from exposure to sunlight and is therefore linked to parental practices and childhood behaviour (Mays, 2010b; Veselka *et al*., 2021).The swaddling of babies was practised during the medieval period in the belief it would help babies to grow stronger, and infants were often kept indoors, and hence, out of the sunlight, to reduce their risk of accidental injury (Orme, 2001; Gilchrist, 2012).

Today, dental trauma is commonly identified in younger children, and is often caused by falls or collisions, particularly as children are developing their motor coordination (Lam *et al*., 2008; Azami-Aghdash *et al*., 2015). The level of care available for younger juveniles influences the likelihood of trauma due to accidents or inter-personal violence (Orme, 2001). The impact of socio-economic status on the risk of young children experiencing dental trauma is debated, although in a clinical study in Brazil, Jorge *et al.* (2009) found children from families with a high level of social vulnerability, were at a greater risk of traumatic dental injuries. In families with low socio-economic status, it is more common for mothers to be in employment. This can result in younger juveniles being cared for by grandparents or older siblings, who may provide less attentive supervision (Veselka, 2019). Conversely, during the medieval period many people worked within the family home, which brought its own hazards: domestic spaces crowded with both people and animals, or trade activities such as brewing or baking, increased the risks of falls and collisions (Walker, 2012b).

3.6.2 Urban and Rural Environments

Studies of medieval populations have concluded that people living in urban areas were at a greater risk of disease and early mortality (Woods, 2003; Kowaleski, 2014; Walter and DeWitte, 2017). However, environmental pollutants and hazards were also present in rural areas, and the movement of people between town and country blurs distinctions between the impact of differing environments on health during childhood (Dyer, 2000; Woods, 2003). Lewis's (2002b) study of four skeletal populations from urban and rural sites dating from A.D. 850-1859, found that post-medieval (post 16th century) industrialisation rather than the medieval (9th-16th century) process of urbanisation, had the greatest impact on non-adult health. Therefore, the following discussion considers both rural and urban environments, focusing on diet, housing, population density, and pollution: factors which shaped older juveniles and adolescents life experiences and their risks of developing disease or sustaining trauma.

Documentary and archaeological evidence suggest that the diets provided to hospital inmates would have been similar to that of poorer people during the medieval period (Gilchrist, 1995; Davis, 2019). Food consisted primarily of bread, fruit, and vegetables, which were often eaten cooked in a grain-based stew or pottage (Gilchrist 1995; DeWitte and Bekvalac, 2010; Gilchrist 2012). Due to the high costs of protein sources, such as meat, dairy, and fish, they comprised a limited part of the diet for lower status people (Bownes *et al*., 2018). Cariogenic foods, those high in sugars and starches, stimulate the development of caries and carbohydrates also promote the accumulation of calculus (Caffell, 2004; Roberts and Manchester, 2010). Consequently, the high levels of carbohydrates in the diets of the medieval poor, encouraged dental disease. Furthermore, the bread eaten by the poor was a coarse brown bread, made with coarser grains of rye and barley, to which peas and beans were added (Davis, 2004). Traditional milling processes introduced fine abrasive grit into the bread, and the leftover husks from the processing of finer flour were also added to the loaves of cheaper bread (Davis, 2004; Mahoney *et al*., 2016). The consumption of a largely grain based diet including poorer-quality bread, therefore caused abrasion on teeth, increasing the rate of tooth wear, damaging tooth enamel, and promoting dental disease (Roberts and Manchester, 2010).

A study by Lewis *et al*. (1995a) comparing the prevalence of sinusitis in urban and rural medieval populations, found the condition to be more common in the urban population. However, other studies on medieval populations from England and Poland found no statistically significant difference, although sinusitis rates were proportionally higher in non-adults from urban environments (Lewis, 2002b; Krenz-Niedbała and Łukasik, 2016). Sinusitis is typically associated with poor air quality (Roberts, 2007). However, in both urban and rural areas, poor quality housing existed, with little ventilation, exacerbating indoor pollution from fires made from wood, animal dung, or straw (Roberts and Lewis, 2002). Domestic industries also contributed to indoor pollution, as did the shared use of houses by people and animals. Intensive polluting industries in towns and their surrounding areas, for example, pottery manufacturing, tanning, and brewing, and the use of coal, coupled with denser populations would have increased the levels of outdoor pollution in urban areas (Dyer, 1989). Many of the raw materials used in urban industries, however, were sourced in rural areas, contributing to air pollution in these environments too (Galloway, 2005; Schofield and Vince, 2003). Consequently, whilst high population density and industries escalated the risks for non-adults of developing sinusitis in towns, factors in both environments contributed to the development of respiratory infections, including sinusitis.

Studies of tuberculosis (TB) in modern populations have found an increased risk of contracting the disease for those living in extreme poverty (Benatar and Upshur, 2010; Oxlade and Murray, 2012; Wingfield *et al*., 2016). Today, TB is often associated with urbanisation, however, Kelmelis and Dangvard Pedersen (2019) found no significant difference in the rates of tuberculosis from rural and urban sites in medieval Denmark. They suggest that populations in both environments would have been at risk of contracting TB albeit from potentially different strains: *M. bovis* from cattle or other mammals, and *M. tuberculosis* from person-to-person transmission (Kelmelis and Dangvard Pedersen, 2019). Medieval children from rural families started working in close contact with animals from seven years of age

(Orme, 2001), placing them at an increased risk of contracting bovine TB, as is still evidenced in the livestock and dairy industry today (Vayr *et al*., 2018). Additionally, pollutants such as the dust from crop processing exacerbated the development of respiratory diseases in medieval rural communities (Roberts and Lewis, 2002). Ethnographic studies have identified specific risk factors for non-adults developing TB, including living in over-crowded, high-density housing (Tornee *et al*., 2004), living in poor quality housing with no running water (Stevens *et al*., 2014), and malnutrition (ul-Haq *et al*., 2010; WHO, 2020). During the medieval period, these factors were often intensified in urban areas (Dyer, 1989).

3.6.3 Migration and Work

Migrants often moved to towns within 10-15 miles of their local area, although larger towns such as London and York attracted migrants from across England (Postles, 2000; Lewis, 2016). Hanawalt (1993) suggests older children were preferred for many domestic and industrial work roles, as they were stronger, had a greater awareness and understanding, and thus, were more useful. Apprenticeships typically began around 14 years of age, though this varied by industry and in response to changing social and economic preferences (Hanawalt, 1993; Orme, 2001; Lewis, 2016). Consequently, adolescents were the predominant age group migrating for work. Newcomers entering urban areas were vulnerable to differing environmental conditions such as high pollution levels, denser populations, and ineffectual waste disposal (Kowaleski, 2014). They were also at a greater risk of infections, from new diseases or strains of infections, against which they had no acquired immunity (Manchester, 1992; Walter and DeWitte, 2017). Furthermore, adolescents who migrated some distance from home were at additional risk from social and economic poverty. Those who did not have a secure work position, or who lost their employment, could find themselves destitute and in need of alms (Rawcliffe, 1984; Orme and Webster, 1995; Lewis, 2016). Without family or community support, such individuals may have relied on urban hospitals to provide shelter and sustenance.

Physically arduous jobs will place strain on different locations of the skeleton dependent on the nature of the tasks undertaken. Identifying specific activity-related causes of joint disease is problematic, however, as they have multifactorial aetiologies (Loe, 2020). As Jurmain *et al*. (2012) argue, many modern clinicians do not accept a simple cause-and-effect relationship between particular occupations and joint pathology. Yet, as the skeletons of adolescents or young adults are still growing, they are more prone to developing joint disease as a consequence of physically demanding or repetitive actions (Gilchrist, 2012; Lewis, 2016). Roberts and Cox (2003) identified medieval industries, in additional to agricultural work, which involved manual or heavy labour that could have resulted in repetitive strain injuries (RSIs). These included quarrying, brick and textile manufacture, metallurgy, glass and woodworking, and leather production (Roberts and Cox, 2003). The duties of lower-skilled adolescents working in service included carrying water, coal, and firewood (Hanawalt, 1993), also placing them at risk of RSIs. Entheseal changes are also used in bioarchaeology as activity markers to explore the impacts of physical activity in past populations (Perréard Lopreno *et al*., 2013; Villotte and Knüsel, 2013; Milella *et al*., 2015). In a study on entheseal changes in preindustrial adult skeletons, held in skeletal collections in Italy and Portugal, Milella *et al*. (2015) found that individuals who had worked in farming were exposed to a greater level of bio-mechanical stress. Furthermore, they found that juveniles were commonly given strenuous work tasks in farming, at an earlier age than in many other sectors (Milella *et al*., 2015). In Lewis' (2016) study of skeletal data from 4,940 adolescents and work in medieval England, a higher prevalence of joint disease was identified in adolescents from urban than rural sites. Thus, conceivably juveniles who worked in agriculture and continued working in physically demanding roles in rural or urban areas as adolescents, could be at an increased risk of developing joint disease.

Schmorl's nodes (SNs) are lesions which form on the vertebral body. In a clinical study in the USA assessing their aetiology, Williams *et al*. (2007) identified heritability rather than environmental factors as the primary determinant. Although other studies have concluded that a direct correlation exists between trauma and the formation of SNs (see Mattei and Rehman, 2014). Therefore, during the medieval period, adolescents who developed SNs may have been genetically predisposed to the condition, which was triggered by physically stressful occupations. Faccia and Williams (2008) found that the location of SNs within the vertebral body determined the level of pain an individual experienced. Thus, only some adolescents would have endured back pain associated with SNs. However, clinical studies indicate that the pain of symptomatic SNs, can be disabling and sufficient to prevent individuals from working (Slotkin *et al*., 2007; Faccia and Williams, 2008). Roberts and Cox (2003) suggest that during the medieval period, it is probable that children from poorer socio-economic backgrounds started work earlier than their peers and were more likely to engage in lower-skilled, physically demanding roles. Consequently, as with joint disease more generally, these children would have been more prone to developing SNs.

Repetitive trauma or load bearing strain are thought to cause osteochondritis dissecans (OCD), lesions which affect the subchondral bone, commonly in the knee, ankle, and elbow joints, although genetic predisposition may also be a factor (Crawford and Safran, 2006; Kocher *et al.*, 2006). Today, OCD is identified more frequently in males than females, possibly due to males typically engaging in more strenuous forms of activity (Accadbled *et al*., 2018; Kessler *et al*., 2018). Lewis' (2016) study into work and adolescents in the medieval period found a higher rate of OCD in those from urban areas and indicated a divergence in labour activities between males and females: higher rates of OCD were found in the knees of females and in the ankles of males (Lewis, 2016). Vikatou *et al*.'s (2017) study into a pre-industrial 19th century farming community in the Netherlands also identified a higher incidence of OCD in the ankles and feet of males compared to females. They suggest that more physically strenuous roles, and work with animals was undertaken by males, placing them at a greater risk of repetitive strain and injury to the feet and ankles (Vikatou *et al.* 2017). Hanawalt (1993) suggests that whilst male servants outnumbered female servants during the medieval period, males had skilled or higher-status roles, whilst females were employed in more menial roles as housemaids and scullery girls. The various work carried out by females in service included cleaning, collecting water, cooking, baking, brewing, and weaving, and has been described by Shapland *et al*. (2015: 282) as "literally backbreaking". Hence, both males and females from urban and rural environments were engaged in work which could cause OCD.

Ascribing a precise cause of a fracture in skeletal remains is not usually possible (Glencross and Stuart-Macadam, 2000; Roberts and Cox, 2003), although, fractures are typically caused by two generic factors: accidental injury (acute trauma or repetitive stress), or intentional violence (Roberts and Manchester, 2010). Clinical studies have identified falls as the primary cause of fracture in non-adults, followed by blunt trauma or collisions (including assaults), primarily occurring during play or sporting activities (Rennie *et al*., 2007; Hedström *et al*., 2010). Most fractures in modern-day studies are located on the lower arm and hand, reflecting the finding that falls are the dominant mechanism of fractures (Hedström *et al*., 2010;

Kaewpornsawan *et al*., 2014). However, as Lewis (2014) states, the mechanisms of trauma vary across time and place due to culturally defined activities and socio-economic conditions. Thus, the activities of children today which result in specific trauma patterns, may not be relevant to past populations.

Judd and Roberts (1998) identified an increased risk of fracture for medieval rural agricultural communities compared to urban populations. They found females were more likely to fracture the forearm, possibly due to trips and falls whilst conducting daily chores (Judd and Roberts, 1998). However, males were identified with a more diverse pattern of fracture location, which Judd and Roberts (1998) suggest, may be related to the multiple tasks undertaken by farm workers. Clinical observations of trauma in traditional Amish farming communities in the USA identified a similar pattern of diverse injury locations due to falls from a height, accidents during outdoor working, and injury caused by animal assaults (Vitale *et al*., 2006; Whitney *et al*., 2021).

Conversely, Lewis (2016) identified a higher prevalence of fractures in urban than rural adolescent (6.6-25-years) populations. Studies of fractures in adults from medieval York and Cambridge, found that most fractures occurred in males and were located on the radius, ulna, and humerus (Grauer and Roberts, 1996; Dittmar *et al*., 2021). This pattern was also replicated in both the non-adult and adult populations from the hospital of St Mary Spital, London (Redfern, 2012a). These injuries were most likely caused by accidental falls onto an outstretched hand or flexed elbow (Grauer and Roberts, 1996; Redfern, 2012a). Grauer and Roberts (1996) argue that many workers in York were engaged in light industries and crafts which predominantly involved the use of the arms, making them vulnerable to trauma. Spiral and avulsion fractures to the tibia and fibula, and ankle injuries were identified by Dittmar *et al*. (2021) in a study of medieval populations from Cambridge, including the non-adult population from the hospital of St John. This type of injury commonly occurs due to a rotational motion where the foot becomes trapped and the leg twists, or by a jump onto an unstable surface (Stirland, 2000; Redfern, 2012a). Therefore, as with upper long bone traumas, they likely reflect incidents involving accidental hazards or work-place injuries (Dittmar *et al*., 2021).

Inter-personal violence is another cause of fractures, and is typically associated with urban environments, with the head and the hands, followed by the upper limbs and torso, the most common sites of injury (Brink *et al*., 1998; Tingne, *et al*., 2014; Milner *et al*., 2015). Dittmar *et al*. (2021) argue that socio-economic status influences a person's occupation and degree of interactions with aggressive people, thus, affecting an individual's risk of sustaining trauma. This is reflected in historical accounts from the medieval period which illustrate incidences of young female servants being beaten whilst in domestic service (Hanawalt, 1993; Lewis, 2016). Furthermore, adolescent males working in London were reportedly drawn to taverns in poorer quarters of the city, where competitive tensions and arguments were resolved by fights and brawls (Hanawalt, 1993; Lewis, 2016).

3.6.4 Co-occurrence of Pathologies

Due to recent advances in bioarchaeology, the relationship between different pathologies and their aetiologies are now being considered. As Brickley *et al*. (2020) state, comprehending health in past populations is complex. Yet our knowledge can be enhanced by drawing together strands of information on social status, environmental factors, and health to discern the relationship between the co-occurrence or co-morbidity of multiple diseases and trauma (Brickley *et al*., 2020). For example, in a clinical study of 461 non-adult deaths in New Mexico, USA, individuals with a congenital heart defect were more likely to have cribra orbitalia, and those with cribra orbitalia were found to have an increased risk of mortality due to respiratory infections (O'Donnell *et al*., 2020). Thus, to gain a broader understanding of the causes and consequences of ill-health in the non-adult populations from medieval hospitals, general stress indicators, specific diseases, and trauma need to be considered together.

In a clinical survey, Jones and Berkley (2014) identified a cyclical relationship between malnutrition, infections, and stress indicators in non-adults. They observed that infections, in addition to food scarcity can result in malnutrition, and the stresses experienced by the body in these circumstances can increase the severity of infectious diseases (Jones and Berkley, 2014). For example, clinical studies conducted in Malawi, Latvia, and Mexico have identified malnutrition as an important causative and exacerbation factor of TB (Zachariah, *et al.*, 2002; Podewils *et al*., 2011; Téllez-Navarrete *et al*., 2021). A lack of vitamin D has also been associated with an increase in TB mortality rates (Téllez-Navarrete *et al*., 2021). In Macallan's (1999) review of clinical studies, the body mass index of patients with TB was found to decrease by 13% in the UK, and by 20% in patients in Malawi. Thus, whilst many individuals who develop TB are already malnourished, the disease itself, further exacerbates levels of nutritional depletion and bodily wasting (Macallan, 1999). Modern-day studies of patients in Sub-Saharan Africa have identified a bidirectional relationship between TB and HIV, and chronic diseases such as diabetes, and also an increase in co-infections of TB with other infections such as cholera and trachoma (Boraschi *et al*., 2008; Young *et al*., 2009). Thus, individuals with TB in the medieval period may also have been at a greater risk of acquiring a range of additional infections or diseases.

Bioarchaeology studies are also exploring the possibilities of relationships between general stress indicators and pathologies with multiple aetiologies. A study by Miller (2018) of non-adult crania (n = 306) from the Spencer R. Atkinson Library, California, found no association between the presence of endocranial lesions and cribra orbitalia. Thus, Miller (2018) suggests there are different aetiologies for the two conditions. Several different aetiologies for the haemorrhage or inflammation of the meningeal vessels which result in endocranial lesions were identified by Lewis (2004). These include meningitis, tumours, vitamin deficiencies, trauma, and TB (Lewis, 2004). Spekker *et al*. (2021) analysed 427 skeletal remains from the Terry Collection, Washington D.C., and identified a statistically significant association between endocranial lesions and TB. Whilst the authors concluded that the presence of endocranial lesions could be considered a diagnostic indicator of TB, they acknowledged that TB is one of many causes of endocranial lesions (Spekker *et al*., 2021). The results of these studies indicate the difficulties in identifying the differing and complex aetiologies of these lesions and stress indicators (Lewis, 2004; Janovic *et al*., 2015).

The risks of an individual sustaining a fracture are also influenced by the presence or absence of certain pathologies. For instance, in a modern-day Swedish study of fractures in infants, metabolic bone diseases were found to be a significant risk factor of infants acquiring fractures in the long bones and ribs due to the reduction in bone mineral content and increased skeletal fragility (Högberg *et al*., 2018). Within the group of metabolic bone diseases, Vitamin D deficiency rickets is particularly associated with an increased risk of bone fracture (Paterson, 2015). It is also probable that dental disease can be inter-related to other pathologies and trauma. Clinical studies have identified an association between calculus and an increased risk of early mortality, and medical conditions including elevated cancer mortality, heart disease, and auto-immune disease (Söder *et al*., 2012; Söder *et al*., 2016; Julkunen *et al*., 2018). Yaussy and DeWitte (2019) identified a negative association between individuals with calculus and survivorship in skeletal populations from medieval London. This suggests a link between calculus and an underlying frailty; however, research has not been conducted to date on any direct relationship between calculus and trauma.

3.7 Summary

This evaluation of bioarchaeological approaches to the study of children has illustrated how theoretical developments have enhanced our understanding of the impact of inter-generational, socio-economic, and environmental factors on the health status of children (Barker, 1990). Deducing the level of care required by an individual, and the ability for a society to deliver that care, is also now plausible (Tilley, 2015). It is recognised that past cultural burial practices and skeletal preservation, in addition to archaeological guidelines and excavation methods, bias interpretations of cemetery demographics. Consequently, archaeologically excavated cemetery populations cannot be assumed to be representative of all those who were interred. Bias was further identified in osteological methods of aging non-adults from skeletal remains (Liversidge *et al*., 2010). Debates continue within the archaeological discipline around the use of assigning biological or chronological ages, and the various terminology utilised for non-adult life stages (Scheuer and Black, 2004; Lewis, 2007; Roksandic and Armstrong, 2011).

The difficulties and advances made in identifying and interpreting disease, trauma, and general stress indicators from non-adult skeletal remains were discussed. Whilst many diseases do not manifest in skeletal changes, the natural growth of bone in non-adults can obliterate evidence of pathology or trauma, which are thus, under-reported in past populations (Roberts and Manchester, 2010). Interpretations of general stress indicators are complex, with some research indicating they are associated with a healthy immune response and others finding a link with reduced life expectancy (Wood *et al*. 1992; Bennike *et al*. 2005; DeWitte, 2014). These theoretical approaches and methodological challenges will inform the discussion in Chapter 6 of this thesis. The next chapter will present the methodology devised to collate and analyse the data gathered for this current research on non-adults from medieval hospital sites.

Chapter 4. Materials and Methods

The following chapter will outline the methods employed in this PhD research which enabled the collection and subsequent analyses of the medieval hospital cemetery data. The chapter first addresses the reasons for the inclusion of the sites utilised in this thesis, before moving on to review methods of data collection and recording. Methods of analysing the data are then considered, followed by an examination of the limitations of this current study.

4.1 Criteria for Inclusion and Exclusion of Sites

A number of criteria were considered when deciding which sites could be included, or should be excluded, from this research. Primarily, archaeologically excavated sites were identified which had a direct relationship to a known medieval hospital, and from which human remains were recovered. In a similar manner to Gilchrist and Sloane's (2005) study of medieval monastic cemeteries, other criteria used to assess the suitability of data for analysis were the geographical location and date of the excavated site. The level of detail and completeness of site excavation reports and osteological reports were also considered. As the focus of this current research is on non-adults, the age range of the individuals excavated from the hospital sites was also an important consideration; a total of 40 sites were identified although only the 27 sites where non-adults were present were included in the statistical analyses (Table 4.1.1). These criteria will be explored in detail below.

Table 4.1.1 List of hospital sites collated for this thesis (the location of each site is illustrated in Figure 34.1.1). * S = small, T = typical, M = medium, L = large. **MNI = minimum number of individuals. UN = unknown.

Site No.	Site Name	Foundation and Closure Dates (A.D.)	Hospital Type	Location	Founder	Religious Order or Rule	Size*	MNI** Analysed	MNI of Non-Adults	Date and Reason for Excavation	Key Reference
1	St Bartholomew, Bristol, Avon	1234-1531	General	Urban	UN	Augustinian	T	33	7 (21%)	1976-78, Research	Price and Ponsford (1998)
2	St Bartholomew, Newbury, Berkshire	1200-1554	General	Urban	UN	Augustinian	T	78	25 (32%)	2004, Commercial	Clough and Witkin (2006)
3	St Margaret, High Wycombe, Buckinghamshire	1229-UN	Leprosarium (male)	Marginal	UN	UN	UN	11	0	1986, Commercial	Farley and Manchester (1989)
4	St John the Evangelist, Cambridge, Cambridgeshire	1195-1511	General	Urban	UN	Augustinian	T	402	61 (15%)	2010-11, Research	Cessford (2015)
5	St Margaret, Huntingdon, Cambridgeshire	1150-1341	Leprosarium	Marginal	Malcolm IV of Scotland, Earl of Huntingdon	UN	T	60	11 (18%)	1993, Commercial	Mitchell (1993)
6	St Leonard, Peterborough, Cambridgeshire	1125-1535	Leprosarium, later General, Almshouse (male)	Marginal	Peterborough Abbey	Benedictine	T	133	7 (5%)	2014, Commercial	McComish *et al.* (2017)
7	St John the Baptist, Chester, Cheshire	1190-1644	General	Urban	Ranulph III, Earl of Chester	Benedictine (Birkenhead Priory)	M	13	4 (31%)	2011, Commercial	Poole (2012)
8	St Mary of the Peak, Castleton, Derbyshire	12th C.-1542	General	Rural	The wife of William Peverel	UN	S	10	2 (20%)	2007-15, Research	Bloxham (2013)
9	St Leonard, Chesterfield, Derbyshire	1171-1547	Leprosarium	Marginal	UN	UN	UN	1	0	2000, Commercial	Witkin (2000)

Site No.	Site Name	Foundation and Closure Dates (A.D.)	Hospital Type	Location	Founder	Religious Order or Rule	Size*	MNI** Analysed	MNI of Non-Adults	Date and Reason for Excavation	Key Reference
10	St Nicholas, Lewes, East Sussex	1085-1547	Leprosarium, later General	Marginal	William de Warenne	Benedictine (Lewes Priory)	T	103	14 (14%)	1994, Commercial	Barber and Sibun (2010)
11	Crouched Friars, Colchester, Essex	1235-1538	Leprosarium, later Almshouse	Marginal	Order of the Holy Cross	Order of the Holy Cross	T	69	16 (23%)	1988, 2007, Commercial	Benfield and Brooks (2007)
12	St Mary Magdalen, Colchester, Essex	1100-1565	Leprosarium	Marginal	Eudo Dapifer at the direction of Henry I	Benedictine, Colchester Abbey	S	40	0	1989, 1995, Commercial	Crossan (2004)
13	St Mary and St Thomas, Ilford, Essex	1140-today	Leprosarium (male)	Marginal	Adeliza, the sister of Payn Fitz John	Benedictine, Barking Abbey	T	18	2 (11%)	1959, Research, 1960, Commercial	Ingram (2006)
14	St Margaret, Gloucester, Gloucestershire	1150-1518	Leprosarium, later Almshouse	Marginal	Gloucester Abbey	Benedictine	S	8	1 (13%)	1991, 2004, Commercial	Evans (2006)
15	St John the Baptist, Lechlade, Gloucestershire	1228-1472	General	Marginal	Isabella de Mortimer	Augustinian	T	52	UN	C.1900, Research	Gloucestershire County Council HER (2008)
16	St Mary Magdalene, Winchester, Hampshire	1158-1643	Leprosarium, later General	Marginal	Bishop Ilchester (?)	UN	M	127	40 (31%)	2009-11, Research	Roffey and Tucker (2012)
17	St Mary Magdalene, Baldock-By-Pass, Hertfordshire	1200-1307	Leprosarium (male)	Marginal	Sir Hugh de Clothall	UN	UN	2	0	2003, Commercial	Thorpe *et al.* (2003)
18	St John the Baptist, Berkhampsted, Hertfordshire	1216-1540	Leprosarium	Marginal	Geoffrey Fitz Piers, Earl of Essex (?)	Order of St Thomas the Martyr of Acon	T	256	46 (18%)	2013, Commercial	Maher (2014)
19	St Peter, St Paul, and St Thomas the Martyr, Maidstone,	1244-1547	General, later Almshouse	Urban	Maidstone College	UN	S	175	9 (5%)	2006-09, Commercial	Henderson and Knight (2013)

Site No.	Site Name	Foundation and Closure Dates (A.D.)	Hospital Type	Location	Founder	Religious Order or Rule	Size*	MNI** Analysed	MNI of Non-Adults	Date and Reason for Excavation	Key Reference
	Kent										
20	St Stephen and St Thomas, New Romney, Kent	1190-1481	Leprosarium, later General	Marginal	Adam Cherryng	UN	T	1	0	2008, Commercial	Holman (2008)
21	St John, New Romney, Kent	14th C.-1495	General	UN	UN	UN	UN	8	UN	2008, Commercial	Holman (2008)
22	St Mary (Maison Dieu), Ospringe, Kent	1232-1516	General	Rural	Henry III	Order of the Holy Cross	T	21	5 (24%)	1977, Commercial	Smith (1979)
23	St John the Baptist, Lutterworth, Leicestershire	1218-1546	General	Rural	Rose de Verdon or her son, Nicholas.	Augustinian	S	25	1 (4%)	1996, 2001, Commercial	Priest and Chapman (2002)
24	St Mary Magdalene, Partney, Lincolnshire	1115-1318	General	Rural	Bardney Abbey	Benedictine	S	33	5 (15%)	2003-04, Commercial	Atkins and Popescu (2010)
25	St Giles, Lincoln, Lincolnshire	1275-1453	General	Marginal	UN	UN	T	6	1 (17%)	2011, Commercial	Allen Archaeology (2012)
26	St Mary Spital, London, Middlesex	1197-1538/40	General	Urban	Walter Brunus and Roisia.	Augustinian	L	5,620	1,076 (19%)	1982-2007, Commercial	Connell *et al.* (2012)
27	St Bartholomew, Castle Acre, Norfolk	12th C.-1350	Leprosarium	UN	Castle Acre Priory	Benedictine	UN	12	0	1967, Commercial	Wells (1967)
28	St Giles, Brompton Bridge, North Yorkshire	12th C.-15th C.	General	Rural	UN	UN	S	35	6 (17%)	1988-1990, Commercial	Cardwell (1996)
29	St Mary, Staxton, North Yorkshire	12th/13th C.-pre-1535	UN	Rural	Priory of Bridlington	Augustinian	UN	1	UN	1950, Research	Brewster (1951)
30	St Mary, York, North Yorkshire	1318-1535	Almshouse (poor priests)	Urban	UN	UN	S	76	2 (3%)	1972, Commercial	Richards *et al.* (1989)
31	St Leonard, Newark,	1125-1640	Leprosarium (male), later	Marginal	Alexander, Bishop of	UN	UN	87	0	1979, Commercial	Bishop (1983)

Site No.	Site Name	Foundation and Closure Dates (A.D.)	Hospital Type	Location	Founder	Religious Order or Rule	Size*	MNI** Analysed	MNI of Non-Adults	Date and Reason for Excavation	Key Reference
	Nottinghamshire		Almshouse (male)		Lincoln						
32	St Mary Magdalene, Bawtry, South Yorkshire	13th C.-1685	General	Urban	UN	UN	T	53	34 (64%)	2010, Research	McIntyre and Hadley (2012)
33	St James, Doncaster, South Yorkshire	1222-1547	Leprosarium, later General	Marginal	UN	Order of St Thomas the Martyr of Acon	T	4	1 (25%)	1961, Commercial	Buckland *et al.* (1989)
34	St John the Baptist, Lichfield, Staffordshire	1135-1571	General, later Almshouse	Urban	Bishop Clinton	UN	T	46	17 (37%)	2016, Commercial	Goacher *et al.* (2016)
35	St John, Stoke-on-Trent, Staffordshire	UN-1545	UN	UN	UN	UN	UN	21	UN	2001, Commercial	Duncan (2002).
36	St Peter, Bury St Edmunds, Suffolk	1135-1538	General (aged or sick priests)	Marginal	Abbot Anslem	Benedictine	T	17	5 (29%)	2012, Commercial	Brooks (2012)
37	St Saviour, Bury St Edmunds, Suffolk	1184-1539	Almshouse (priests, male)	UN	Abbot Samson	Benedictine	M	16	0	1989-90, Commercial	Caruth and Anderson (1997)
38	St Leonard, Coventry, Warwickshire	Mid-12th C.-1280	Leprosarium	UN	UN	UN	UN	2	0	2007, Commercial	Palmer (2007)
39	St Mary Magdalene, Bidlington, West Sussex	13th C.-16th C.	Leprosarium (male), later Almshouse	Rural	The Braose Family	UN	T	46	3 (7%)	1959-60, Commercial	Lewis (1964)
40	St James and St Mary Magdalene, Chichester, West Sussex	1118-1621	Leprosarium (male), later Almshouse	Marginal	'Good Queen Maud', consort of Henry I (?)	UN	T	384	105 (27%)	1986-87, 1993, Commercial	Magilton *et al.* (2008)

4.1.1 Geographical Locations

The sites chosen for inclusion in this research are all located within England (Figure 4.1.1). This was to allow for the exploration of national social, religious, and economic circumstances, each of which influenced the founding and organisation of medieval hospitals. Hospitals in Wales and Scotland were not included in the analysis as they were not politically united with England until A.D. 1536 and 1707, respectively. Additionally, medieval hospital sites with associated human skeletal remains have not yet been excavated in Wales or Scotland. Watson (2006) argues the English hospital was distinct from its Continental counterparts. Whilst the Roman Catholic Church was powerful across much of medieval Europe, other European countries were subject to different national political and economic controls, and social customs, which could invalidate, or complicate, comparisons (Waley and Denley, 2001). However, with this caveat in mind, a selection of excavated or historically researched medieval hospital cemetery sites in Europe are discussed in Chapter 6, to place English hospital sites within a broader international medieval context. Hospital sites from northern and western Europe were chosen as these sites are more comparable than hospitals elsewhere in the world from the same period, as they were influenced by relatively similar environmental, religious, and social conditions to those in England (Holmes, 2001).

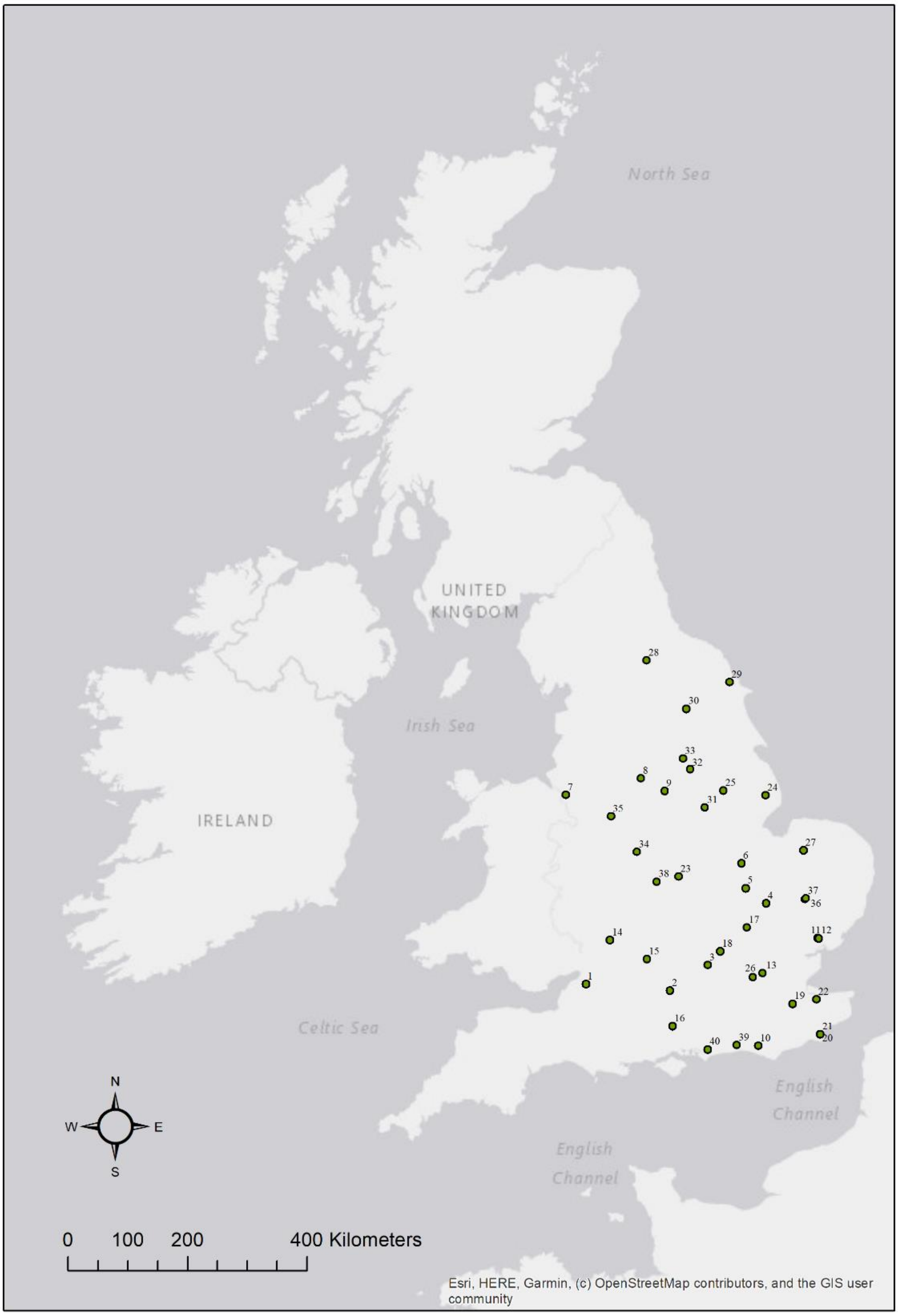


Figure 4.1.1 Location map of English medieval hospitals utilised in this thesis (numbers relate to the order of sites in Table 4.1.1 and Appendix 1), (Hookway and Squires, 2020: 43).

4.1.2 Date of Sites

Medieval hospital cemetery sites dating from A.D. 1066-1550 are discussed in this research. Independent hospital foundations were first created after the Norman invasion of 1066, while the Dissolution of the Monasteries in 1536-1541, effectively signalled the closure of many English hospitals (Orme and Webster, 1995). The life span of hospitals varied considerably due to demand for places, changes in patronage, or finances. Some sites declined less than a century after being founded, others declined and were later re-founded, whilst some sites continued in use for many centuries (see Chapter 1). Establishing the exact dates of medieval burials can be problematic as grave goods, and thus dating evidence, were rarely placed in burials (Gilchrist, 2008). The chosen date range of A.D. 1066-1550 therefore encapsulates the effective start and end dates of the existence of medieval hospitals in England. This has ensured all hospital cemeteries which have been excavated and archaeologically or historically dated to this period have been included in the analysis.

Phasing of cemetery use was only recorded at four sites, namely St Bartholomew, Newbury (Clough and Witkin, 2006), St Leonard's, Peterborough (McComish *et al*., 2017), St Mary Magdalene, Colchester (Crossan, 2004), and St Mary Spital, London (Connell *et al*., 2012). The first two sites were phased by stratigraphic sequential layers of burials, and thus, calendar dates were not ascribed to the different phases. Archaeological finds from the latter two sites, enabled calendar dates to be associated with each subsequent phase.

4.1.3 Age Range of Individuals

The focus of this research is on non-adults. Current English law defines a child as "anyone who has not yet reached their eighteenth birthday" (HM Government, 2018: 5). Defining a child in the medieval period is problematic (see Chapters 2 and 3). Therefore, in order to create a useful system to classify and assess the osteological data, the current definition of a child, as an individual under the age of 18 years, has been used in this thesis.

Guidelines for establishing the age at death of skeletal remains were first developed in the 1960s and 1970s (see Moorrees *et al*. 1963; Ubelaker, 1978). Whilst these guidelines are still used, methods have been modified and a number of standards for determining age at death are now used by osteologists. Methods used to determine non-adult age at death are often not stated in osteology reports until the latter 1970s. Osteologists today do typically report the standards followed (for example those developed by Brothwell, 1981; Buikstra and Ubelaker, 1994; Scheuer and Black, 2000) and use mixed methods to estimate age at death, including skeletal development and epiphyseal fusion, and dental development and tooth eruption. This has increased the accuracy with which age can be estimated, although the use of different standards can result in differing age categories being used which can hamper comparisons between sites. Methods used in establishing the age ranges, which were used in the analyses of the hospital non-adult data, will be discussed below (Section 4.3.4).

4.2 Methods of Data Collection

To conduct thorough analyses of all archaeologically excavated medieval hospital cemetery sites in England, it was necessary to ensure data from all sites were collated to allow inter-site comparisons to be made. To achieve this, all excavated and reported sites needed to be identified. In addition to identifying published reports, the ADS website was searched for grey literature. Museums, HER officers, and archaeological units were contacted to find any relevant reports held in their archives. Data collection was completed at the end of August 2019. Two additional excavated medieval hospital cemetery sites, namely Thornton Abbey (Lincolnshire) and St Leonard's (Northumberland), were known to the author during the collection of data, however, the site reports were still being prepared for publication and were not available prior to the completion of this thesis.

4.2.1 Museums

Museums often act as repositories for archaeological units project reports and archaeological material, including excavated human remains which are being stored and not reburied. In total, 273 museums in England were systematically contacted by email and asked if they held any reports or material relevant to this current research. In total, 126 (46%) museums responded, 10 of which held records relating to medieval hospital sites. These records were then searched to identify sites where excavation had occurred, and human skeletal remains were identified.

4.2.2 Historic Environment Records

Historic Environment Records (HERs) are managed by local authorities to maintain information relating to buildings, landscapes, sites, monuments, and archaeological finds, for the purposes of planning and development, and education. Of the 84 HERs, 62 have digitised their holdings, which were accessed through the Heritage Gateway website (heritagegateway.org.uk). The following search terms were used: date range, 1000 AD–1600 AD; key words, 'hospital' and, 'hospital and cemetery'. The records of 22 HERs are not currently available on the internet, therefore these were individually contacted by email to request a search of the HER records for any relevant sites and reports. As noted above (Section 4.2.1), the records within the search results were then examined to identify relevant sites for this present research.

4.2.3 Archaeological Data Service (ADS)

The ADS was established in 1996 as an "accredited digital repository for heritage data" (Archaeological Data Service, n.d.) for use by commercial archaeological companies, community archaeology groups, and academics. The website contains grey literature, published archaeological reports, and digital data including datasets, images, and maps (*ibid*.). The website was searched for relevant grey literature and reports using the same search criteria aforementioned for the HER.

4.2.4 Archaeological Units

Archaeological units conduct excavations for both commercial and research purposes. Larger units, for example, Museum of London Archaeology (MOLA) and Oxford Archaeology (OA), publicly record information relating to their work on their websites. The websites of large commercial units were accessed to identify additional sites which have yet to be recorded on the HER or added to the ADS. Archaeological units were contacted directly to request any copies of reports which were identified through the above means (HER, ADS, and company website searches) but were not digitally available.

4.2.5 Unpublished Data

The osteological data for two sites, St Mary and St Thomas, Ilford (Essex), and St Mary Magdalene, Winchester, were not available from the above sources.

Therefore, in August 2019, visits were made to the relevant depositories of the original site records (Redbridge Museum and Heritage Centre, and the University of Winchester, respectively) in order to obtain the data from the original osteology reports.

4.3 Recording Data

During the data collection process, a total of 40 archaeologically excavated burial sites associated with medieval hospitals were identified (see Appendix 1). Four sites were excavated in two discrete programmes of archaeological excavation (this does not include sites which were excavated in a series of excavations over successive years as part of a single programme of work). Crouched Friars, Colchester, was excavated in 1988 (by Donald Shimmin) and in 2007, by Colchester Archaeological Trust (Benfield and Brooks, 2007). St Mary and St Thomas, Ilford, was also excavated in two programmes, firstly, in 1959 by Kenneth Marshall, and in 2005, by Museum of London Archaeology Service (Ingram, 2006). St Margaret's, Gloucester (Gloucestershire), was first excavated in 1991, by Gloucester Excavations Unit and again in 2004, by Cotswold Archaeology (Evans, 2006). St Mary Spital, London, was also excavated by Museum of London Archaeology in two programmes of work, from 1982-1991 (Thomas *et al*., 1997) and from 1991-2007 (Connell *et al*., 2012). For each of these sites, the data from each site report has been amalgamated and presented as a single dataset for the purpose of the current research.

4.3.1 Creation of the Hospital Cemetery Database

From the 40 hospital sites, the total number of non-adults identified for inclusion in this research was 1,506. To manage and analyse such a large data set, the relevant data relating to non-adults were collated in a series of four independent databases in Microsoft Excel 2013. The first Excel spreadsheet, Database 1, recorded geographical information, site name, date of excavation, chronological date of the site, the minimum number of individuals (MNI) recorded at the site, the number and proportion of non-adults, the hospital 'type', any mother house or cathedral to which a hospital was dependant, key references, and whether a full osteology report was available. The second spreadsheet, Database 2, recorded data relating to the entire cemetery population (i.e. non-adults and adults) which had been excavated and analysed at each site including the general layout of the cemetery and categorisation of the demographic data by age and sex, in order to contextualise the proportions and burial locations of the non-adults. Any anomalies recorded within the burials (e.g. multiple burials or inverted burials) were also recorded. The third spreadsheet, Database 3, contained the raw data which were to be statistically analysed, for each non-adult individual that had been osteologically analysed and recorded. This included age, details of pathology and trauma, place of burial (for example in a cemetery or within a church), and any associated archaeological evidence, such as the use of coffins or burial shrouds. The fourth spreadsheet, Database 4, used the same column headings as the third database, but the data were adjusted and standardised in order to make it comparable and facilitate analysis in IBM SPSS. For example, age ranges were made consistent to facilitate the analysis of the proportions of individuals within the different age ranges at each hospital site.

4.3.2 Site Data

Characteristics for each hospital which may have influenced which individuals could have entered, or been buried at these sites, such as location and founding legislation, were included in Database 1. The location of the hospital (urban, marginal, rural), the dedication of the hospital to a particular saint, any religious rule a hospital adhered to (e.g. the Augustinian Rule), and whether or not the site was located on a pilgrim route, were recorded. Relevant documented admission policies, such as entry permissions relating to pregnant women and policies related to the care and education of children, were also included.

4.3.3 Burial Practice

The majority of burials considered in this research, including those of non-adults, were located within a cemetery associated with a hospital. At several sites, such as St Bartholomew’s, Bristol (Price and Ponsford, 1998), burials were located within buildings, such as chapels, or to cardinal points in relation to a building or feature, for example a path; these characteristics were also recorded within Database 2. Where evidence for coffin or shroud burials, in the form of nails, stains or pins were stated in the archaeology reports, for example at Litten, Newbury (Clough and Witkin, 2006), this was also documented. The majority of individuals were buried in a supine position. Body positions which differ from this norm, for example prone burials or individuals with flexed limbs, were only recorded in eight site reports. Therefore, due to insufficient numbers, these data are not included in statistical analysis but are considered in the discussion (Chapter 6).

4.3.4 Osteology Data: Age Ranges

The age ranges and terminology used by osteologists differs across the site reports examined in this study (Table 4.3.1). As previously discussed in Chapter 3, the lack of a standardised approach to categorising, recording, and presenting age data from skeletal remains contributes to the difficulties of comparing different populations (Halcrow and Tayles, 2008). The secondary data used in this thesis originates from reports produced over a period of six decades; the earliest osteology reports are from sites excavated in the 1960s and the most recent excavation and osteological analysis occurred in 2016. Consequently, as stated above (Section 3.3), the use of differing methods and standards for estimating age at death of non-adults means the degree of accuracy and age ranges used varies between reports, which can cause difficulties when using secondary data. Different terminologies are used in bioarchaeological literature to describe individuals under 18 years of age, including ‘sub-adult’, ‘pre-adult’, and ‘non-adult’. Within this thesis the latter term, ‘non-adult’, is used throughout to avoid any confusion from the use of multiple terms.

Table 4.3.1 Examples of age ranges and terminology used in osteology reports.

St John the Baptist, Lichfield, Staffordshire (Goacher *et al*., 2016).		**St Mary Magdalene, Bawtry, South Yorkshire (McIntyre and Hadley, 2012).**		**St Mary Spital, London (Connell *et al*., 2012).**	
Age Range	**Terminology**	**Age Range**	**Terminology**	**Age Range**	**Terminology**
1-12 months	Infant	0-4 years	Infant	1-11 months	Postnatal Infant
1-6 years	Young Juvenile	5-9 years	Child	1-5 years	Early Childhood
7-12 years	Older Juvenile	10-14 years	Child	6-11 years	Later Childhood
13-17 years	Adolescent	15-19 years	(Possibly Male / Female)	12-17 years	Adolescent
<18 years	Non-adult	<18 years	Sub-adult	<18 years	Sub-adult

Buikstra and Ubelaker (1994) devised the first widely used standards for recording human remains. They developed the following age categories for recording an individual's age at death: foetal (<birth), infants (birth–3 years), children (3–12 years), adolescents (12–20 years), young adults (20–35 years), middle adults (35–50 years), and old adults (50+ years). However, as demonstrated in Table 4.3.1, the age ranges used by osteologists do vary. In a study of medieval monastic cemeteries, Gilchrist and Sloane (2005) used the non-adult age ranges of 0–5 years for infants, 6–10 years for children, 11–15 years for immature, and 16–25 years for young adults. It would be desirable to use these same age ranges to make the results of this current study comparable with data used by Gilchrist and Sloane (2005). However, the use of the younger age range would not enable the distinctions of neonates, infants, and children to be made, and the older age ranges do not conform to the age categories used in most of the osteology reports obtained for this current research.

Non-adult remains were identified at 27 of the 40 sites included in this thesis. The majority of osteological reports used numerical age categories to group individual's age at death. Nominal categories (infant, child, immature) were used for individuals from St Margaret, Huntingdon (Cambridgeshire) (Duhig, 1993). Specific ages were used at seven sites where six or less non-adults were identified, for example the one non-adult from St Margaret, Gloucester, was determined to be 14 to 15 years of age (Gilmore, 2006), and the individual from St James, Doncaster (South Yorkshire), was identified as six to seven years old (Bayley, 1989). For the current research, the most frequently used age ranges in the osteological reports were chosen as this involved the minimum manipulation of the osteological age data (Table 4.3.2). It must be noted though, that these age categories are not entirely satisfactory, as biologically, the category of 'neonate' can be defined as birth to 27 postnatal days, and the term 'infant', used from 28 days to one year of age (Scheuer and Black, 2004; Lewis, 2007).

Many reports do not contain separate categories for perinates, neonates, or infants, therefore, when appropriate, statistical analyses on demographic data were conducted twice: once with the age categories shown in Table 4.3.2, and again, with a single 'younger juvenile' category for individuals from birth to 5 years of age. The publication of more detailed osteological reports, or the deposit of data with an organisation such as the Archaeological Data Service, including, for example, long bone lengths or stages of tooth eruption as a minimum standard, would allow for greater access to information which would permit researchers to interrogate data more fully and make more meaningful site comparisons possible.

Table 4.3.2 Age categories used in the data analysis for this thesis.

Nominal Category	**Numerical Category**
Perinate	28 weeks gestation–7 postnatal days
Neonate	Birth–11 months
Infant	1–2 years
Child	3–5 years
Older Juvenile	6–11 years
Adolescent	12–<18 years
Non-adult	<18 years

In order to make the osteological data from different reports comparable, a method used to adjust age data was adopted (see McIntyre and Hadley, 2012; Penny-Mason and Gowland, 2014). This involved manipulating age data from within reports to average the number of individuals across an age range and translate the data into appropriate age categories. For example, due to poor preservation and fragmentation, four individuals at St John the Baptist, Chester, were broadly aged between 1-12 years old at death (Hepburn, 2012). In order to use this data in analyses, the four individuals were divided most appropriately between the age categories of 0-5 years, 6-11 years, and 12-17 years, resulting in two individuals placed in each of the 0-5 years and 6-11 years categories.

4.3.5 Sex

The estimated sex of non-adults cannot be reliably determined as the distinguishing male and female characteristics of an adult pelvis and cranium do not develop until puberty (Scheuer and Black, 2004). Therefore, the sex of most individuals considered in this research is not stated in osteological reports and consequently is not recorded in Databases 3 or 4. However, there are two exceptions to this. Firstly, at St Nicholas, Lewes, for example, the age range of 15-20-years was used within the osteological analysis and three of the five individuals belonging to this age group were assigned as male or possibly male (Barber and Sibun, 2010) (see discussion in Chapter 3). Secondly, aDNA analysis can be used to determine the sex of an individual. aDNA analysis was conducted on an older child from St Mary Magdalene, Winchester, which identified this individual as a male (Tucker, n.d.).

The estimated sex of non-adult individuals is rarely known however, and therefore this data is not included in the statistical analysis, although it is referred to in the discussion (Chapter 6).

4.3.6 Pathology and Trauma Terminology

The terminology used in osteology reports can vary for the same or similar pathological conditions. Thus, in order to make comparisons between cemetery populations, terminology relating to a similar condition was considered together (Buikstra and Ubelaker 1994). For example, recorded observations of periostitis and periosteal reaction, both relating to subperiosteal new bone formation, were entered in the database under subperiosteal new bone formation (Weston, 2008).

4.3.7 Pathology

All information relating to pathology or trauma was recorded on the third and fourth databases. As discussed in Chapter 3, there are issues with identifying the aetiology of many indicators of disease. Alongside pathological lesions, standard skeletal markers which are commonly used to infer stress in an individual's life (i.e. cribra orbitalia, dental enamel hypoplasia and subperiosteal new bone formation) were also included in these databases (see Dawson-Hobbis 2017).

The level of information relating to pathology in osteology reports varies considerably. For example, the severity of cribra orbitalia can be defined according to an established grading system (e.g. Buikstra and Ubelaker, 1994). However, the application of this process will depend on the preservation of the skeletal orbital elements and the time available to the osteologist to conduct analyses. Consequently, whilst many osteology reports do state the degree of cribra orbitalia observed on skeletal remains, others state only its presence or absence. Similarly, the presence or absence of skeletal elements is not routinely recorded in osteological reports, and the extent or severity of pathologies such as Vitamin D deficiency (rickets) or tuberculosis, are not always evident from secondary data sources. Thus, due to the nature of secondary data, crude prevalence rates of pathology and trauma are used in this thesis instead of true prevalence rates, and pathologies are recorded as present or absent, without consideration of the severity of the condition. This may result in conditions such as cribra orbitalia being over-reported as observations of low scoring grades of lesions do not necessarily signify pathology.

Within the above caveats, all pathological information recorded in the osteology reports was included in the database. The presence or absence of each pathology was recorded in individual columns within the Microsoft Excel spreadsheet, using disease classifications, for example congenital conditions, metabolic conditions, infectious disease, and dental disease (Table 4.3.3) (for a glossary of osteological terms see Appendix 2). When sufficient data were available, further consideration and analyses of individual pathologies was made. There are numerous different terms and categories used within bioarchaeology for the same pathology. Additional difficulties can arise when classifying pathologies, for example, ankylosis is a joint condition but can be caused by trauma or infections such as tuberculosis (Roberts and Manchester, 2010). Thus, classifications used by Roberts and Manchester (2010) are followed within this thesis.

The completeness and preservation of skeletal remains directly impacts the availability of pathological information. Within Databases 3 and 4, preservation and completeness have been recorded where this information is available. It should be noted that the absence of a pathology may be due to missing or poorly preserved skeletal elements. As stated above, the presence of skeletal lesions recorded in secondary data, does not necessarily reveal the severity of a disease, and conversely the absence of a pathological indicator on skeletal remains does not signify that an individual did not experience disease. For example, if the orbital roofs of an individual were not present, it would not be possible to observe if the individual had cribra orbitalia. Therefore, crude prevalence rates (the total number of individuals observed with a pathology), rather than true prevalence rates (the total number of elements, e.g. teeth, affected), were recorded and analysed.

Table 4.3.3 Pathology and trauma reported for non-adults in osteological reports, listed under group headings used in analysis.

Group	Individual Pathologies and Trauma
Congenital Conditions	Bathrocephaly, Congenital Fusion, Congenital Syphilis, Cranial Anomalies, Developmental Dysplasia of the Hip, Klippel-Feil Syndrome, Scoliosis, Spina Bifida Occulta, Spinal Disorder, Spondylolysis.
Metabolic Conditions	Cribra Orbitalia, Kidney Stone, Porotic Hyperostosis, Vitamin D deficiency (Rickets), Vitamin C deficiency (Scurvy).
Infectious Disease	Bowel Infection, Fungal Infection, Leprosy, Non-specific Infection, Osteitis, Osteomyelitis, Otitis Media, Osteolytic Lesions, Otosclerosis, Subperiosteal new bone formation, Rhinitis, Sinusitis, Tuberculosis, Treponemal Disease.

Group	Individual Pathologies and Trauma
Joint Disease	Ankylosis, Intervertebral Osteochondrosis, Invertebral Disc Disease, Osteoarthritis, Osteophytes, Schmorl's Nodes, Septic Arthritis, Spinal Degenerative Changes.
Miscellaneous Pathology	Age Discrepancy, Bone Cysts, Chondroma, Endocranial Lesions, Neoplastic Disorder, Osteochondroma, Osteoid Osteoma, Torticolis.
Dental Condition	Abscess, Calculus, Caries, Dental Anomalies, Dental Enamel Hypoplasia, Periapical Lesions, Periodontal Disease.
Trauma	Avulsion Injury, Blunt Force Injury, Dental Trauma, Fracture, Osteochondritis Dissecans, Perthe's Disease, Sharp Force Injury, Soft tissue Trauma.

4.3.8 Trauma

Akin to pathology, the level of information regarding trauma in the different osteology reports is variable. All information relating to trauma recorded in osteology reports was included in Databases 3 and 4. The presence or absence of any trauma has been recorded in individual columns within the Microsoft Excel spreadsheet, and these have been grouped into types of trauma (e.g. fracture, sharp force injury, and blunt force injury), location (e.g. long bone or rib), and state of healing (e.g. healed or unhealed). Grouping trauma in this manner enabled the comparison of individual types of traumas. Where there was insufficient data, grouping trauma types (e.g. ante or peri mortem trauma, fracture, dental trauma, and blunt force trauma) provided useful insights into the differences in the injuries sustained by non-adults at the different hospital sites. Where trauma fulfilled multiple criteria, for example, a healed greenstick fracture of the tibia, the trauma was recorded and analysed as appropriate within the groupings of type and location of fracture and state of healing.

4.4 Data Analysis

The data contained within the Microsoft Excel Database 4, were analysed using IBM SPSS Statistics 26 to identify statistically significant differences or similarities between the demographic profiles of sites, and the health status of individuals.

4.4.1 SPSS

SPSS is a software package used within the social sciences to investigate quantitative data (see Dawson, 2014; Lewis *et al*., 2016; Bownes *et al*., 2018). The statistical tests used in SPSS were selected on the basis of the type and number of groups of data to be analysed, and the normality of the data distribution. Principle component analysis was used to identify any relationships between the variables in the dataset in order to make the following analysis more meaningful (Argyrous, 2011). Descriptive tests were initially run in SPSS to establish the distribution of the data; this included the mean, standard deviation, and spread of the data (Hinton, 2014). As age data were grouped into age ranges, it became categorical as opposed to scale data (Pallant, 2020). Therefore, the decision was made to use chi-square for most of the statistical analyses conducted in this current research as the hospital types, pathology, and trauma data are also categorical.

There are some constraints with the chi-square test and certain assumptions that need to be met. SPSS will assess whether any cells in the data table have an expected frequency of less than five. If 20% or more of the cells have an expected value of less than five, the test results cannot be meaningfully interpreted (McCormick and Salcedo, 2020; Pallant, 2020). A minimum sample of 50 is required for certain statistical testing and therefore in order to conduct analyses the younger four age categories were combined and the individuals in the <18 years of age category were equally distributed between the remaining categories. This resulted in the use of three age categories for most chi-square tests: younger juvenile, older juvenile, and adolescent. Significance was assigned to the result of each test when the p value was equal to or less than 0.05 (*ibid*.).

Three datasets were created for the analyses of non-adults from medieval hospital sites. The first, Group A, contains all 1,506 non-adults reported from hospital sites considered in this thesis. The second dataset, Group B, excludes all of the 1,070 non-adults from St Mary Spital, London, and was created due to the large size of the dataset from St Mary Spital and the unique environment of medieval London which may have influenced health and socio-economic status. Thus, Group B consists of the 436 non-adults recorded from all other hospital sites, excluding St Mary Spital. During the excavations at St Mary Spital, numerous large multiple burials were identified, each containing eight to 45 individuals. These burials were termed ‘catastrophe burials’ by the excavators and those buried within them are believed to be inhabitants of London who died during episodes of famine or disease during the early 14th century (Connell *et al*., 2012). A total of 571 non-adults were recorded from these large multiple burials. They are included in Group A of this current study expressly because they were buried within the hospital cemetery. Additionally, their status as London residents or hospital inmates at the time of death, is not known for certain. However, as it is possible that these non-adults were not hospital inmates, a third group, Group C (n = 935), was created, excluding the 571 non-adults from the catastrophe burials.

4.4.2 How is the Data Displayed?

The data are displayed using the most relevant means of visual display in order to clearly illustrate the data and the results from analyses. SPSS and Microsoft Excel contain several options for displaying data in various graph formats. Results produced from different analytical tests are best displayed in particular formats. For example, bar graphs are used predominantly in the following results chapter as they are the best format to display categorical data and the results of chi-square analysis (Shennan, 1997; McCormick and Salcedo, 2020). Line graphs are used where appropriate to depict relationships between categorical and continuous data, for example, to represent the different proportions of non-adults in each age category in Groups A, B, and C (Pallant, 2020). Scatterplots can illustrate the positive or negative relationships and strength between variables by displaying them around the intersection of two axis and has been utilised to display the results of PCA analysis (*ibid*.).

4.5 Limitations of the study

There are a number of limitations to this research that need to be acknowledged and are discussed below.

4.5.1 Type of Site (Hospital Cemeteries)

Huggon (2018) has estimated that 1,146 hospitals were founded in England during the medieval period. Therefore, the 40 sites considered in this current research represent only a small proportion of the sites which may have existed (3.5%). However, not all hospitals had their own dedicated cemetery, and, in such instances, inmates were buried in the local parish cemetery (see Chapter 2). Conversely, some hospital cemeteries were used to bury members of the hospital staff, benefactors, and members of the local parish community who requested burial within the hospital cemetery (Cessford, 2012). Thus, a fundamental issue with the data is that it is not possible to say with certainty that all of the individuals identified from hospital cemetery sites were hospital inmates.

As discussed above (Section 4.1.2), medieval cemeteries and individual burials within them are problematic to date or phase with certainty, as within medieval Christianity, the interment of grave goods was not a common practice (Gilchrist and Sloane, 2005). Graves were often unmarked or may have been marked with wooden crosses which could have survived for a number of years, as indicated by an exact superimposition of one individual above another, at St Leonard's, Newark (Bishop, 1983). However, these crosses would have decayed over time, and therefore, successive re-use of cemetery sites has frequently resulted in intercutting of burials, as at St Nicholas, Lewes (Barber and Sibun, 2010). These past actions can be used to phase burials, although the time frame and intervals for the use and re-use of the cemetery cannot be determined.

4.5.2 Size of Cemetery Populations

The size of the excavated medieval hospital site populations varies from a single individual at St Leonard's, Chesterfield (Witkin, 2000), St Stephen and St Thomas, New Romney (Kent) (Holman, 2008), and St Mary, Staxton (Brewster, 1951), to 10,156 individuals at St Mary Spital, London (Connell *et al*., 2012). Large cemetery assemblages are defined archaeologically as those consisting of more than *c.*100 burials (Mays *et al*., 2018). Of the 40 sites identified for this study, nine (22.5%) consisted of an excavated cemetery population of more than 100 individuals, six (15.0%) sites consisted of 50-100 individuals, and 24 (60.0%) sites consisted of fewer than 50 individuals. No osteological data were available for one site (2.5%), namely St John, Stoke-on-Trent (Staffordshire), due to the poor level of preservation of the human remains (Duncan, 2002).

The statistical analyses of sample populations of variable sizes were problematic in terms of producing results with true significance. Gilchrist and Sloane (2005) encountered the same issues with their demographic data from medieval monastic cemetery sites. Hence, percentages rather than numbers are used to enable comparisons to be made across hospital sites. The resultant data can then be used appropriately to explore similarities and differences in the populations and determine trends within and between the cemetery sites.

4.5.3 Archaeological Field Methodology

The majority of sites (n = 30, 75%) considered in this research were excavated due to commercial development. Therefore, the physical extent of archaeological excavation was determined by the parameters of the development as opposed to the area of archaeological interest. Most excavations, regardless of being commercially or academically focused, had time and/or financial constraints placed upon them. As a result, only three cemetery sites have been fully excavated: St Leonard's, Peterborough (McComish *et al*., 2017), St Mary Magdalene, Partney (Lincolnshire) (Atkins, 2005), and St James and St Mary Magdalene, Chichester (Magilton *et al*., 2008). However, there are caveats even with these sites. The actual hospital of St Mary Magdalen, Chichester, and its associated chapel were not excavated. Thus, it is possible that any burials placed within the chapel were not identified during the excavation (*ibid*.). St Mary Spital, London, is the largest hospital and cemetery site excavated in England and has produced the largest number of individuals included in this current research. Yet, the site was not considered fully excavated by the project directors (Connell *et al*., 2012). A portion of the cemetery was truncated by construction projects in the 1920s which destroyed burials within the area, and analysis of burial density suggests approximately 18,000 people were originally interred within the hospital cemetery (*ibid*.).

Sites such as St Margaret, Huntingdon, were excavated as a rescue project when human remains were identified during construction work (Mitchell, 1993). The time constraints on the archaeological work at this site resulted in the use of a JCB with a toothed bucket which damaged the buried remains (*ibid.*). Even when time constraints are not so rigid, methodological decisions such as the use of hand excavation, block lifting small or fragile human remains, and sieving the soil from within graves, all impact the level of damage to human remains which can occur during excavation, and the level of retrieval, particularly of small bones (Connell *et al*. 2012). These factors affect the amount of information available to osteologists. However, the preservation of human bone is also affected by the burial environment, as well as any subsequent development within the boundaries of a site. At the cemetery associated with St John the Baptist, Berkhamsted

(Hertfordshire), a total of 231 individuals were excavated and analysed (Young Langthorne, 2014). This included 46 non-adults of whom 27 (58.7%) were less than 25% complete, and the majority were graded as ‘moderately’ to ‘poorly’ preserved (*ibid*.). Difficulties with obtaining data due to the completeness and preservation of human bone are inherent to archaeological populations. Therefore, a level of bias in any data recorded from archaeological and osteological samples is inevitable.

4.5.4 Completeness of Site Excavation Reports

The information contained in archaeological site reports varies considerably. This is, in part, due to the date when the excavation took place and the accepted standards for archaeological reporting at the time. Excavations at the hospital of St John, Lechlade, are the earliest recorded excavation considered in this research, dating from c.1900 when no recording standards existed (Gloucestershire HER, 2008). Although human remains are mentioned in the excavation notes, they were reburied without any form of analysis being conducted (*ibid*.). The increasing number of rescue archaeology excavations from the 1960s led to a “publication crisis” (Richards and Hardman, 2008: 178). Due to a lack of appropriate funding and resources, only a synopsis of excavations was often published. Archaeological professional guidelines created by the Chartered Institute for Archaeologists (2015) recommend that all project findings are published. However, due to issues of time and/or funding, full analysis of skeletal remains and the publication of complete site reports can occur many years after excavation.

The Online Access to the Index of Archaeological Investigations (OASIS) was developed in 2003. This provided the first national standard recording form and online repository for all archaeological researchers and contractors in the United Kingdom to submit site records and reports to an online database, following the completion of fieldwork (Richards and Hardman, 2008). The OASIS forms are validated by local Historic Environment Offices (HERs) before being made available on the Archaeology Data Service (ADS) website. Whilst OASIS and the ADS provide a means of recording site information, archiving reports, and a platform for publishing a minimum level of information for archaeological fieldwork, timeframes for delivering detailed excavation and post-excavation reports do not yet exist (*ibid*.). For this current research, all available data were included in the analysis, and any discrepancies in the contents of reports, such as differing numbers of individuals recorded, were given consideration when site comparisons were made.

Difficulties were presented in selecting cemetery data of the appropriate chronological date range. Where skeletal remains were dated within the period of interest (A.D. 1066-1550), the data are included in the analysis. Where wider dates for contexts have been given, for example A.D. 1100–1850, the data have not been included, as it is likely that a proportion of the individuals would not have lived and died during the chronological limits of this research (Crossan, 2004). At St Mary Magdalen's Hospital, Colchester, the cemetery was divided into four phases: Phase 1 (early 12th-c. mid-13th C.), Phase 2 (c. mid-13th C.-1610), Phase 3 (1610-19th C.), and Phase 4 (19th C.-1995). The first two phases covered the period from the early twelfth century to 1610, however twenty-eight skeletons were dated to Phase 2–3, which extends the time frame of these burials to the early 1700's (*ibid*.). The decision was made to include these individuals in this study as it is likely that many of the individuals were buried during the relevant medieval period.

4.5.5 Completeness of Osteological Reports

The secondary data on non-adult skeletal remains used in this thesis were obtained from published and unpublished archaeology and osteology reports. Therefore, the completeness of osteological reports of individuals from hospital cemetery sites was an important factor in conducting verifiable comparative analysis. As discussed in Chapter 3, due to time and financial considerations, and the completeness and preservation of the human remains, the level of osteological analysis which can be conducted on an assemblage varies considerably between sites. In some instances, only a proportion of individuals excavated from archaeological sites are osteologically analysed. For example, at St John the Evangelist, Cambridge, all individuals (n = 404) were analysed to determine the basic demography of the cemetery (age and sex). However, of the 61 non-adults excavated, only 15 (25%) were included in a study to identify trauma and pathology (Dodwell, 2015).

Reporting of the findings also differs. The reports from some sites remain unpublished whilst detailed publications of the osteological analysis and findings have been produced from other sites. All available data have been utilised as fully as possible and were included in data analysis for this current research as appropriate. Where conflicting minimum numbers of individuals have been given in final site reports, the original osteological report has been obtained wherever possible, and the data from this alone has been used. For example, Richards *et al*. (1989) report of excavations at the Horsefair, York, states 75 individuals were recovered, and 73 individuals are recorded on skeletal record sheets, however 76 individuals are recorded in the final osteological report. The excavation of St Mary and St Thomas, Ilford, by Marshall in 1959 and 1960, and subsequent osteological analysis of human remains in 1985 (Roberts,1985), have not been published. The original notes from the excavation and the analysis were consulted for this current research. However, the data did not tally, therefore the osteological analysis recording forms were scrutinised and the information for this current study was taken directly from these forms.

4.6 Questions and Hypotheses

In order to systematically investigate the non-adult and hospital site data, a series of questions and hypotheses were created (Appendix 3). The research questions have been placed into five groups: demography, disease, general stress indicators, trauma, and burial practices. By exploring the demographics of hospital sites an understanding can be gained of how different types of hospitals were used by non-adults. The analysis of rates of disease, stress indicators, and trauma present within these populations, provides a means of investigating the influence of social, economic, and environmental factors on individual's lives. The questions are presented in Appendix 3 alongside their associated hypotheses.

4.7 Ethics

This research is based upon the osteological analysis of human remains. However, during the data collection phase of this research, no skeletal analysis was conducted by the author. Instead, data were obtained from existing osteological reports. Therefore, no specific ethical considerations relating to the treatment of human remains was required, and a 'Non-Ethics Disclaimer' form was completed as per Staffordshire University's ethics policy. All sources of data have been acknowledged and referenced accordingly.

4.8 Summary

Archaeological and osteological reports were obtained from a total of 40 medieval hospital cemetery sites. The relevant age, pathology, and trauma data were extracted from the reports. These were subsequently recorded in Microsoft Excel 2013 spreadsheets and analysed in IBM SPSS Statistics 26. The differences in the quantity of data from the various sites was resolved by repeating analyses and including, or omitting, particular sites (i.e. St Mary Spital, London) to identify any bias in the results and account for the differing social and environmental influences of London. The following chapter will present and explore the results from the analyses of the site data which are structured following the questions in Appendix 3, under the categories of demography, disease, general stress indicators, trauma, and burial practices.

Chapter 5. Results

5.1 Introduction

Using the methodology outlined in Chapter 4, the current chapter presents the results obtained from data collection and the analyses conducted. As discussed in the previous chapter, each of the statistical analyses performed on the data were conducted three times: firstly, on Group A data (n = 1,506), comprising all non-adults from medieval hospital sites; secondly, Group B (n = 436), consisting of non-adults from medieval hospital sites though excluding all non-adults from St Mary Spital, London; and thirdly, Group C (n = 935), which excludes only the individuals from St Mary Spital categorised as burial type 'D'.[1]

Non-adults were not reported at 13 hospitals collated for this study, including four sites where no demographic data were obtained from the skeletal remains. Consequently, data from 27 hospitals were used in the following analysis. A total of 7,854 skeletons were osteologically analysed and reported from these sites, comprising 6,348 (80.8%) adults and 1,506 (19.2%) non-adults. Tables 5.1.1, 5.1.2, and 5.1.3 detail the hospitals where non-adult skeletal remains were identified, grouped by the original location type for the hospital foundation (i.e. urban, marginal, or rural). The dates of when osteological analysis occurred are not routinely given in publications, therefore the dates of archaeological excavation and of the report publication are given as an indicator of when the skeletal remains were osteologically examined.

[1] St Mary Spital 'D' type burials are defined as 'the larger burial pits … used in response to a catastrophic emergency' and are thought to be inhabitants of London rather than hospital inmates (Connell *et al*., 2012: 14).

Table 5.1.1 Hospitals founded in urban locations.

Site No.	Name	Foundation Type	Adults: number	Adults: percentage	Non-adults: number	Non-adults: percentage	Date of Excavation	Date of Publication
1	St Bartholomew, Bristol, Avon	General	26	79	7	21	1976-78	1998
2	St Bartholomew, Newbury, Berkshire	General	53	68	25	32	2004	2006
4	St John the Evangelist, Cambridge, Cambridgeshire	General	341	85	61	15	2010-11	2015
7	St John the Baptist, Chester, Cheshire	General	9	69	4	31	2011	2011
19	St Peter, St Paul, and St Thomas the Martyr, Maidstone, Kent	General	166	95	9	5	2006-09	2013
26	St Mary Spital, London, Middlesex	General	4,544	81	1,076	19	1982-2007	2012
30	St Mary, York, North Yorkshire	Almshouse	77	97	2	3	1972	1989
32	St Mary Magdalene, Bawtry, South Yorkshire	General	19	36	34	64	2010	2012
34	St John the Baptist, Lichfield, Staffordshire	General	29	63	17	37	2016	2016

Table 5.1.2 Hospitals founded in marginal locations.

Site No.	Name	Foundation Type	Adults: number	Adults: percentage	Non-adults: number	Non-adults: percentage	Date of Excavation	Date of Publication
5	St Margaret, Huntingdon, Cambridgeshire	Leprosarium	49	82	11	18	1993	1993
6	St Leonard, Peterborough, Cambridgeshire	Leprosarium	126	95	7	5	2014	2017
10	St Nicholas, Lewes, East Sussex	Leprosarium	89	86	14	14	1994	1998
11	Crouched Friars, Colchester, Essex	Leprosarium	53	77	16	23	2007	2007
13	St Mary and St Thomas, Ilford, Essex	Leprosarium	16	89	2	11	1959	Unpublished
14	St Margaret, Gloucester, Gloucestershire	Leprosarium	7	88	1	13	2004	2006
16	St Mary Magdalene, Winchester, Hampshire	Leprosarium	87	69	40	31	2009-12, 2015	Unpublished
18	St John the Baptist, Berkhampsted, Hertfordshire	Leprosarium	210	82	46	18	2013	2014
25	St Giles, Lincoln, Lincolnshire	General	5	83	1	17	2011	2012
33	St James, Doncaster, South Yorkshire	Leprosarium	3	75	1	25	1961	1989
36	St Peter, Bury St Edmunds, Suffolk	General	12	71	5	29	2012	2012
40	St James and St Mary Magdalene, Chichester, West Sussex	Leprosarium	279	73	105	27	1986-87, 1993	2008

Table 5.1.3 Hospitals founded in rural locations.

Site No.	Name	Foundation Type	Adults: number	Adults: percentage	Non-adults: number	Non-adults: percentage	Date of Excavation	Date of Publication
8	St Mary of the Peak, Castleton, Derbyshire	General	8	80	2	20	2011-15	2015
22	St Mary (Maison Dieu), Ospringe, Kent	General	16	76	5	24	1977	1979
23	St John the Baptist, Lutterworth, Leicestershire	General	24	96	1	4	1996, 2001	2002
24	St Mary Magdalene, Partney, Lincolnshire	General	28	85	5	15	2003	2010
28	St Giles, Brompton Bridge, North Yorkshire	General	29	83	6	17	1988-90	1996
39	St Mary Magdalene, Bidlington, West Sussex	Leprosarium	43	93	3	7	1959-60	1964

5.2 Dataset Variables

A principal component analysis (PCA) was conducted to identify the presence of any relationships between six variables within the non-adult hospital dataset, used in analyses and presented in this chapter below (age category, hospital type, hospital location, hospitals serving pilgrims, hospital dedication, and coffined burial). The first two principal components, accounting for 68.6% of the variance within the data, are hospital location and hospital type. Figure 5.2.1 illustrates that hospital location (0.824, 0.076) and type of hospital (0.866, -0.011) are closely correlated, and as such the data on non-adults in relation to these two variables is strongly related. Coffined burials (0.736, -0.016) are also positively related to hospital location and type, whilst hospitals serving pilgrims (-0.814, -0.167) and hospital dedications (-0.657, -0.259) are negatively related to these factors. Age category (-0.387, 0.896) is an outlier on the scatterplot and is not strongly related to the other five variables.

Figure 5.2.1 Scatterplot illustrating the correlation between six hospital data variables.

Figure 5.2.2 further illustrates the relationship between hospital location and the type of hospital. A total of nine hospitals were situated in urban environments, 12 in marginal locations, and six in rural localities. It is notable that hospitals which originated as leprosaria were predominantly in marginal locations, whilst general hospitals were founded mainly in urban (n = 8) areas though also in marginal (n = 1) and rural (n = 5) sites. In the current study, only one hospital was founded as an almshouse, and this was in an urban location. However, hospitals which were converted into almshouses were located in urban (n = 3), marginal (n = 3), and rural (n = 1) locales.

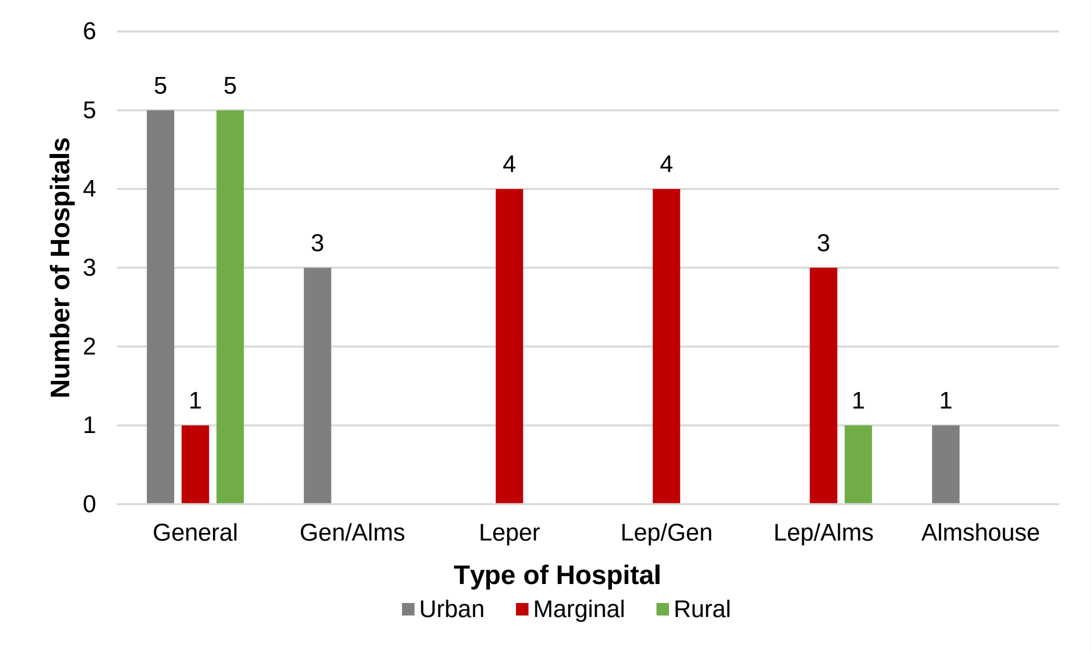


Figure 5.2.2 Types of hospitals and their locations.

Due to the close relationship between hospital location and hospital type, data and analysis conducted on hospital location only, is presented throughout this chapter. The hospital location variable is more discreet than the hospital type variable, as many hospitals changed function overtime. In most instances, the date of a change in a hospitals primary function is not recorded, and the use of the cemetery cannot necessarily be aligned with the specific function of a hospital.

5.3 Completeness and Preservation

The completeness and preservation of skeletal remains were recorded in all of the osteological reports consulted for this thesis. This is an important factor in understanding and interpreting the health of past populations as poor preservation or the absence of skeletal elements prohibits the observation of pathology or trauma (Roberts and Manchester, 2012). The level of completeness for the majority of non-adult skeletal remains from Group A is 50-74% present (n = 1,153, 76.6%) (Table

5.3.1). This is influenced by the selection criteria of Connell *et al*. (2012) in their study of skeletal remains from St Mary Spital, London. Due to the large number of individuals recovered from this site (n = 10,957), only remains with a minimum level of 35% completeness were analysed. In Group B, approximately one third of non-adult skeletal remains were less than 25% complete (n = 134, 30.7%), whilst 194 (44.5%) non-adult skeletal remains were more than 50% complete. Sites particularly affected by low levels of skeletal completeness include St Margaret, Huntingdon (15/15, 100%), and St John the Baptist, Chester (4/4, 100%), where all non-adult remains were less than 25% complete. Additional sites with substantial numbers of non-adult skeletons less than 25% complete include St John the Evangelist, Cambridge (29/61, 47.5%), St John the Baptist, Berkhamsted (23/46, 50.0%), and St Mary Magdalene, Bawtry (26/34, 76.5%).

Table 5.3.1 Completeness of non-adult remains from 27 medieval hospital sites.

Completeness	Group A (n = 1,506)		Group B (n = 436)	
	Number	**%**	**Number**	**%**
75 – 100% (0)	111	7.4	111	25.5
50 – 74% (1)	1,153	76.6	83	19.0
25 – 49% (2)	89	5.9	89	20.4
<25% (3)	134	8.9	134	30.7
Unrecorded (4)	18	1.2	18	4.1

Based on osteological reports, the preservation of the majority of non-adult remains from the 27 hospital sites was classified as ‘good’ (n = 1,206, 80.1%) (Table 5.3.2). When the non-adult individuals from St Mary Spital, London, were removed from the data, the highest proportion of non-adult (n = 136, 31.2%) skeletal remains were also classified as being in a ‘good’ state of preservation. There is a greater spread of skeletal preservation rates in Group B, and whilst the number of individuals with ‘moderate’ preservation is the same in Groups A and B (n = 111), proportionately, they account for 7.4% of non-adults in Group A and 25.5% in Group B.

Table 5.3.2 Preservation of non-adult remains from 27 medieval hospital sites.

Preservation	Group A (n = 1,506)		Group B (n = 436)	
	Number	%	Number	%
Excellent (0)	73	4.8	73	16.7
Good (1)	1,206	80.1	136	31.2
Moderate (2)	111	7.4	111	25.5
Poor (3)	52	3.5	52	11.9
Very Poor (4)	19	1.3	19	4.4
Destroyed (5)	1	0.1	1	0.2
Unrecorded (6)	44	2.9	44	10.1

5.4 Demography

This section explores the demographic composition of non-adults reported from medieval hospitals. Chi-square analysis is used to test hypotheses 1, 2 and 3 (see Appendix 3) to identify if any statistically significance differences exist between the presence of non-adults by age category and hospital location, the specific provision of hospitality to pilgrims, and by cemetery phasing.

5.4.1 Minimum Number of Individuals (MNI)

To date, a total of 1,506 non-adults (<18 years of age) have been recorded at English medieval hospitals. As acknowledged in Chapter 4, while disarticulated skeletal remains were identified at hospital sites, they are rarely included in osteological analyses. Therefore, it is probable that the number of non-adults recovered from hospital sites is greater than the figures recorded.

5.4.2 Age

The demography data from all hospital sites were combined to produce a single data set. Table 5.4.1 shows the age at death of non-adults and adults who were analysed from medieval hospital sites.

Table 5.4.1 The age and sex of adults and non-adults from 36 hospital sites where skeletal remains were identified.

Age Category	Sex Unknown No.	Sex Unknown %	Male No.	Male %	Female No.	Female %	Total No.	Total %
Perinate (in utero – birth)	75	1.0	0	0.0	0	0.0	75	1.0
Neonate (birth – 11 months)	42	0.5	0	0.0	0	0.0	42	0.5
Infant (1-2 years)	78	1.0	0	0.0	0	0.0	78	1.0
Child (3-5 years)	106	1.4	0	0.0	0	0.0	106	1.4
Older Juvenile (6-11 years)	498	6.4	1	0.0	0	0.0	499	6.4
Adolescent (12-17 years)	665	8.5	21	0.3	4	0.1	690	8.8
Non-adult (<18 years)	16	0.2	0	0.0	0	0.0	16	0.2
Non-adult Total	**1,480**	**18.9**	**22**	**0.3**	**4**	**0.1**	**1,506**	**19.3**
18-25 years	0	0.0	649	8.3	526	6.7	1,175	15.0
26-35 years	0	0.0	963	12.3	800	10.2	1,763	22.6
36-45 years	0	0.0	849	10.9	538	6.9	1,387	17.7
+46 years	0	0.0	421	5.4	309	4.0	730	9.3
Adult (>18 years)	853	10.9	248	3.2	153	2.0	1,254	16.0
Adult Total	**853**	**10.9**	**3,130**	**40.1**	**2,326**	**29.8**	**6,309**	**80.7**
Overall Total	**2,333**	**29.9**	**3,152**	**40.3**	**2,330**	**29.8**	**7,815**	**100.0**

The non-adult demographic data were analysed using two sets of age categories, as appropriate: firstly, seven age categories were used, distinguishing between perinate, neonate, infant, child, older juvenile, adolescent, and general non-adult (<18 years of age) (Table 5.4.2). Secondly, as discussed in Chapter 4, the younger four age categories, perinate, neonate, infant, and child categories, were combined into a single younger juvenile category (Table 5.4.3). These data were combined due to the low numbers of perinates and neonates recorded from medieval hospital sites which, when explored by hospital location and by pathology or trauma, were generally insufficient to conduct statistical analyses.

Table 5.4.2 Non-adult demographic data using seven age categories.

	Group A		Group B		Group C	
Age Category	**Number**	**%**	**Number**	**%**	**Number**	**%**
Perinate	75	5.0	4	0.9	53	5.7
Neonate	42	2.8	38	8.7	40	4.3
Infant	78	5.2	55	12.6	68	7.3
Child	106	7.0	66	15.1	93	9.9
Older Juvenile	499	33.1	139	31.9	298	31.9
Adolescent	690	45.8	123	28.2	367	39.3
Non-adult	16	1.1	11	2.5	16	1.7
Total	**1,506**	**100.0**	**436**	**100.0**	**935**	**100.0**

Table 5.4.3 Non-adult demographic data using three age categories.

	Group A		Group B		Group C	
Age Category	**Number**	**%**	**Number**	**%**	**Number**	**%**
Younger Juvenile	301	20.0	163	37.4	254	27.2
Older Juvenile	499	33.1	139	31.9	298	31.9
Adolescent	690	45.8	123	28.2	367	39.3
Non-adult	16	1.1	11	2.5	16	1.7
Total	**1,506**	**100.0**	**436**	**100.0**	**935**	**100.0**

Figure 5.4.1 shows an increase in the number of individuals from neonates (n = 42, 2.8%) to older juveniles (n = 499, 33.1%) and adolescents (n = 690, 45.8%) in Group A. Although, the number of perinates (n = 75, 4.9%) is greater than that of neonates (n = 42, 2.8%). The Group B data illustrates a consistent increase in the numbers of individuals in the perinate group (n = 4, 0.9%) through to the older juvenile category (n = 139, 31.9%), and then a decrease in the number of adolescents (n = 123, 28.2%). The demographic profile for Group C follows the same pattern as that for Group A.

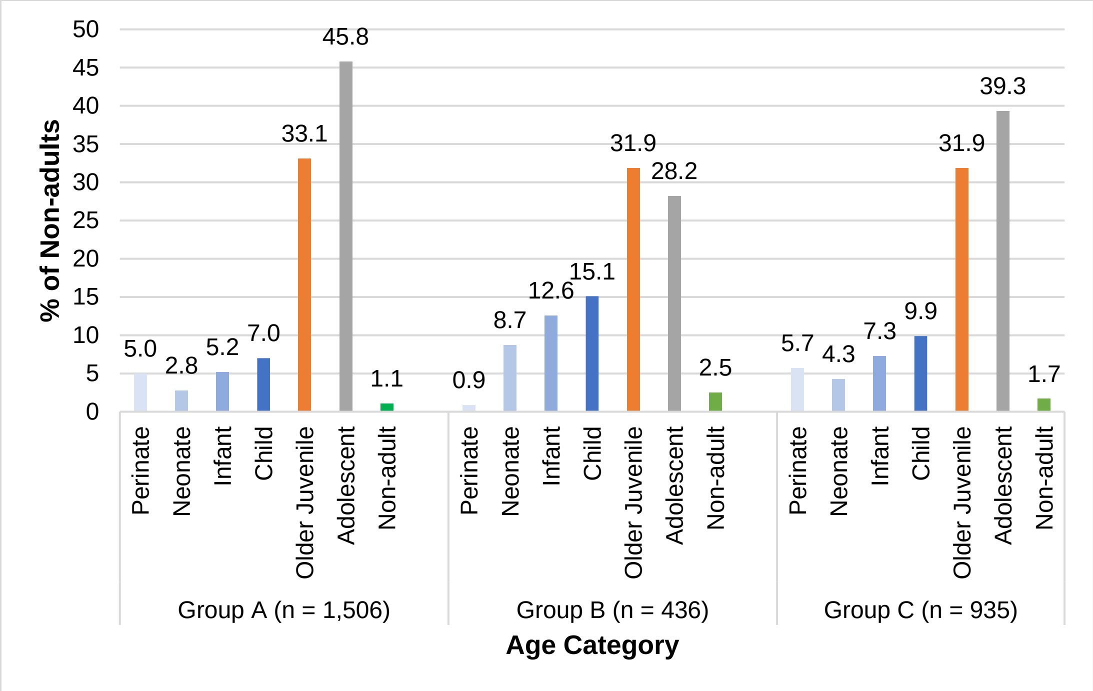


Figure 5.4.1 Age at death distribution of non-adults using seven age categories.

The demographic profile of each non-adult group, using four age categories, is illustrated in Figure 5.4.2. A similar demographic pattern is seen in Groups A and C, with an increase in the number of individuals from younger juveniles to adolescents. In Group A, there were 301 (20.0%) younger juveniles, 499 (33.1%) older juveniles, and 690 (45.8%) adolescents. An additional 16 (1.1%) individuals were categorised as ‘non-adults’, those under 18 years of age that could not be assigned to a narrow age grouping. When the individuals from St Mary Spital are excluded in Group B, a reverse in this trend is evident, with the numbers of individuals decreasing from younger juveniles to adolescents, comprising 163 (37.4%) younger juveniles, 139 (31.9%) older juveniles, and 123 (28.2%) adolescents, with 11 (2.5%) non-adults.

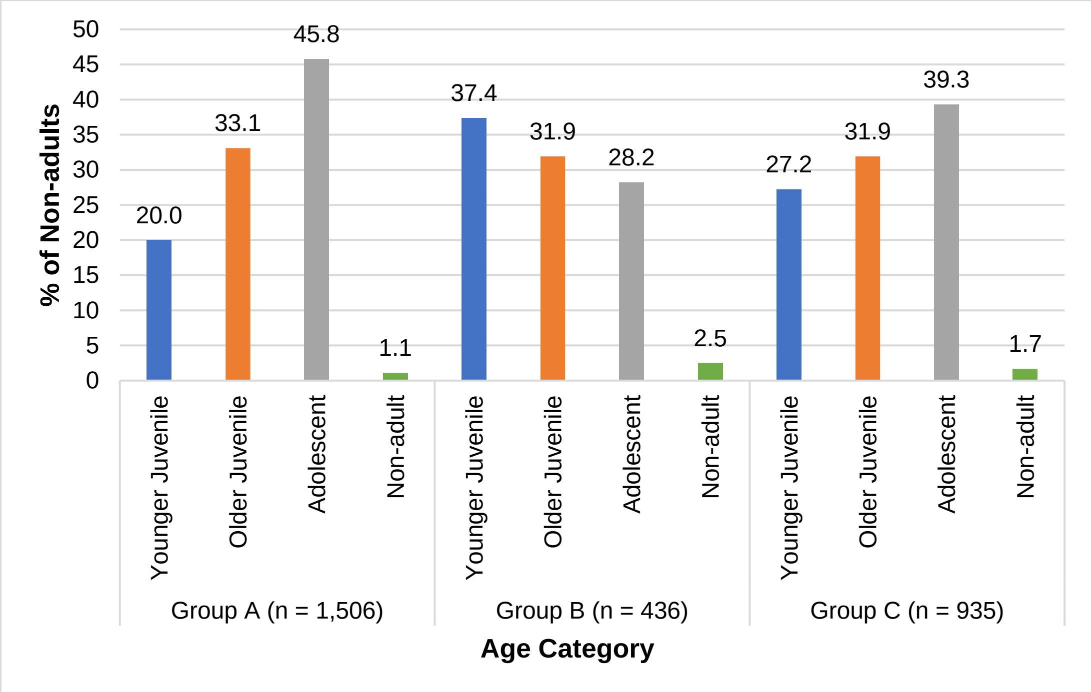


Figure 5.4.2 Age at death distribution of non-adults using four age categories.

The difference in the proportions of non-adults in each age category within groups A, B, and C, can be seen in Figure 5.4.3. The greatest difference occurs between Group A and Group B. Group B has a higher proportion of individuals in the child category (3-5 years old, n = 66, 15.1%) than Group A which has the lowest proportion (n = 106, 7.0%). Whilst there is less of a difference in the cumulative proportions of non-adults in Groups A and C, Group C has a slightly higher proportion of children (n = 93, 9.9%) and older juveniles (n = 298, 31.9%). Of all three groups, Group A has the greatest proportion of adolescents (n = 690, 45.8%). The reasons for these differences will be explored in Chapter 6.

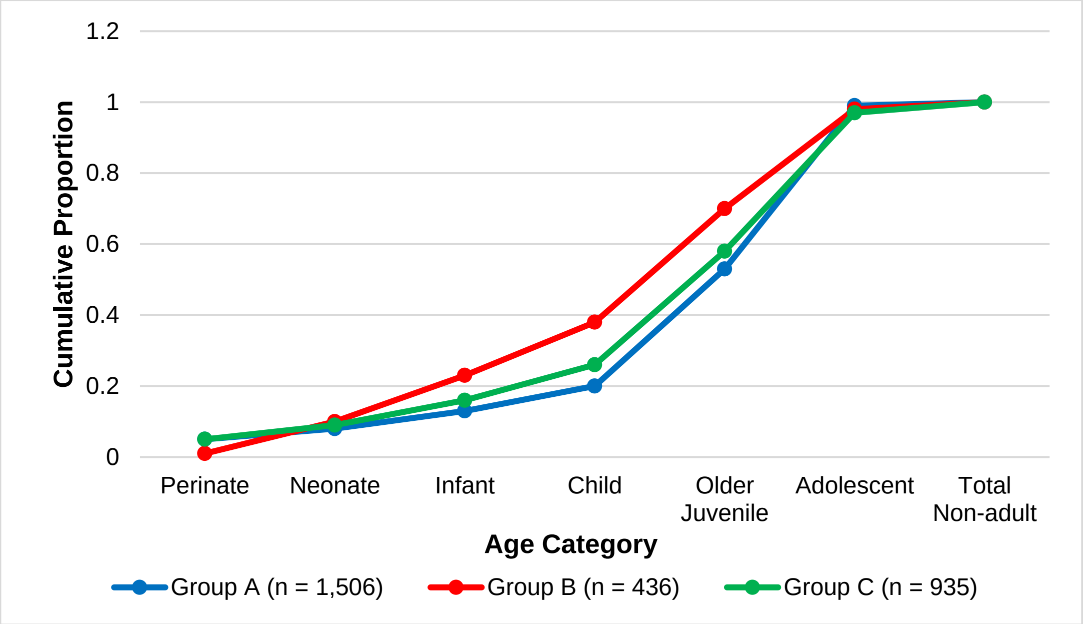


Figure 5.4.3 The cumulative age distribution in Groups A, B, and C.

Figure 5.4.4 shows that in Groups A (n = 301) and C (n = 254), younger juveniles, namely those aged between 28 weeks gestation and five years old, do not increase in number in a linear manner. Perinates (Group A: n = 75, 4.9%; Group C: n = 53, 5.7%) constitute a higher number than neonates which account for 2.8% (n = 42) of non-adults in Group A and 4.3% (n = 40) in Group C. The numbers of individuals increase within the infant category to 5.2% (n = 78) in Group A and 7.3% (n = 68) in Group C, and further increase in the child category, comprising 7.0% (n = 106) in Group A, and 9.9% (n = 93) in Group C. However, when all individuals from St Mary Spital are excluded from the data (Group B, n = 153), the trend differs. The graph line increases with each age category: perinates (n = 4, 0.9%) account for the lowest number of non-adults, and children (n = 66, 15.1%) comprise the highest proportion. This indicates that a higher proportion of perinates, but a lower proportion of neonates, infants, and children were buried at St Mary Spital than in the other hospital cemeteries.

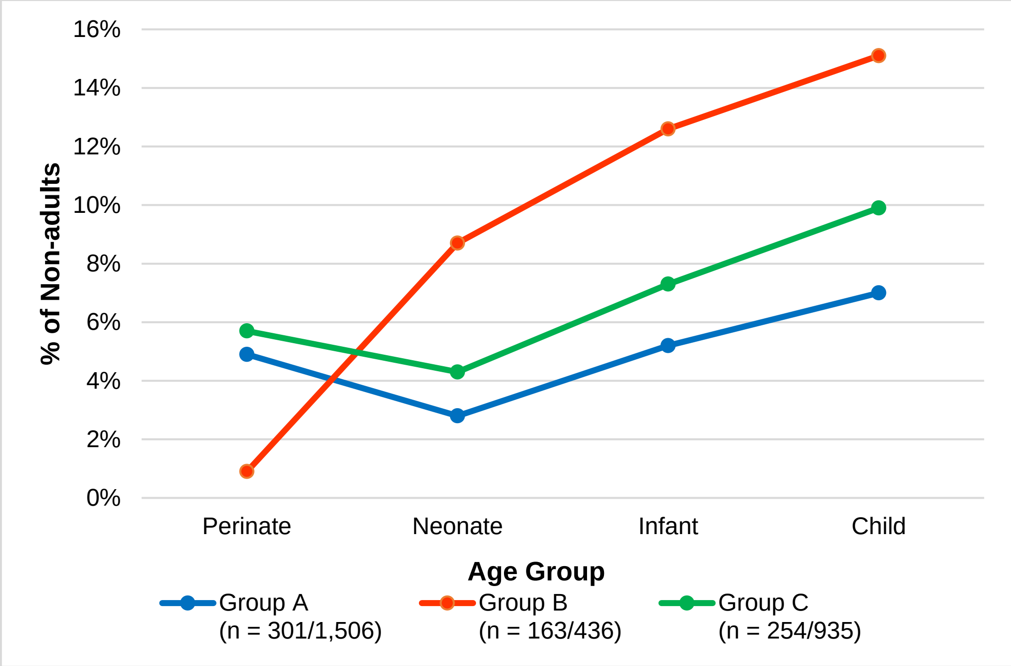


Figure 5.4.4 Percentages of non-adults aged 0–5 years at death.

5.4.3 Sex

The sex of 25 adolescents and a single juvenile were recorded in osteological reports from 11 hospital sites (Table 5.4.1). Nine individuals were recorded as male, 13 as possible male, and four as possible female, giving a total ratio for male to female non-adults of 5.5:1.0. However, as this is a small proportion of the total number of non-adults analysed from hospital sites (26/1,506, 1.7%), it is not possible to extrapolate this ratio to the wider population. The sex of a nine- to 11-year-old juvenile male, from St Mary Magdalene, Winchester, was ascertained through aDNA analysis (Tucker, n.d.). The sex of the 25 adolescents was determined by pelvic and cranial morphology. The limitations of estimating sex in non-adult individuals are recognised within bioarchaeology (Lewis, 2007; Mays, 2010a) and hence, the sex of 17 non-adults were recorded as possible rather than definitive. Due to the small number of non-adults who were sexed, these data could not be statistically analysed.

5.4.4 Age and Hospital Location

The 27 hospitals where non-adults were identified were categorised by location type: urban, marginal, and rural. Tables 5.4.4 to 5.4.6 show that within Groups A and C the greatest numbers of non-adults were identified at urban hospital sites.

Conversely, most non-adults in Group B were from marginal locations. Within the younger juvenile age category, it is notable that 71/75 (94.7%) perinates were reported from a single urban hospital, St Mary Spital, London. Of the 42 neonates, 28 (66.7%) were from sites which originated as leprosaria. The proportions of infants and children are more evenly distributed: 41/77 (53.2%) infants were identified at urban sites and 36 (46.8%) at marginal sites. Of the 98 children, 54 (55.1%) were from urban hospitals, 44 (44.9%) were recorded from marginal sites, and a single (1.0%) child was identified at a rural hospital.

Table 5.4.4 The numbers and percentages of non-adults within each hospital location in Group A (n = 1,506).

Age Category	**Urban**		**Marginal**		**Rural**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Younger Juvenile	186	15.1	114	45.1	7	31.8
Older Juvenile	418	34.0	80	31.6	6	27.3
Adolescent	627	50.9	59	23.3	9	40.9
Total	**1,231**	**100.0**	**253**	**100.0**	**22**	**100.0**

Table 5.4.5 The numbers and percentages of non-adults within each hospital location in Group B (n = 436).

	Urban		**Marginal**		**Rural**	
Age Category	**Number**	**%**	**Number**	**%**	**Number**	**%**
Younger Juvenile	46	28.6	114	45.1	7	31.8
Older Juvenile	57	35.4	80	31.6	6	27.3
Adolescent	58	36.0	59	23.3	9	40.9
Total	**161**	**100.0**	**253**	**100.0**	**22**	**100.0**

Table 5.4.6 The numbers and percentages of non-adults within each hospital location in Group C (n = 935).

	Urban		**Marginal**		**Rural**	
Age Category	**Number**	**%**	**Number**	**%**	**Number**	**%**
Younger Juvenile	139	21.1	114	45.1	7	31.8
Older Juvenile	217	32.9	80	31.6	6	27.3
Adolescent	304	46.1	59	23.3	9	40.9
Total	**660**	**100.0**	**253**	**100.0**	**22**	**100.0**

In all three groups, younger juveniles were identified in higher proportions at marginal hospitals and lower proportions at urban sites, whilst the reverse trend was found for adolescents. This difference was statistically significant (p = <0.01) in Group A (χ^2 (4, n = 1,506) = 129.185, p = 0.000), Group B (χ^2 (4, n = 436) = 14.534, p = 0.006) and Group C (χ^2 (4, n = 935) = 62.061, p = 0.000).

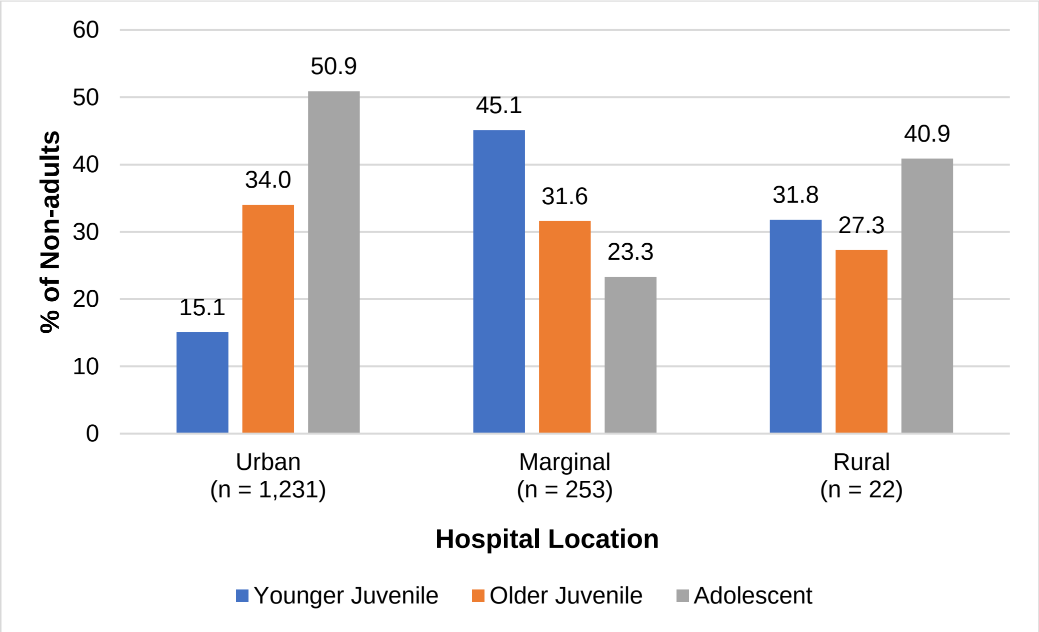


Figure 5.4.5 Distribution of age categories by hospital location in Group A (n = 1,506).

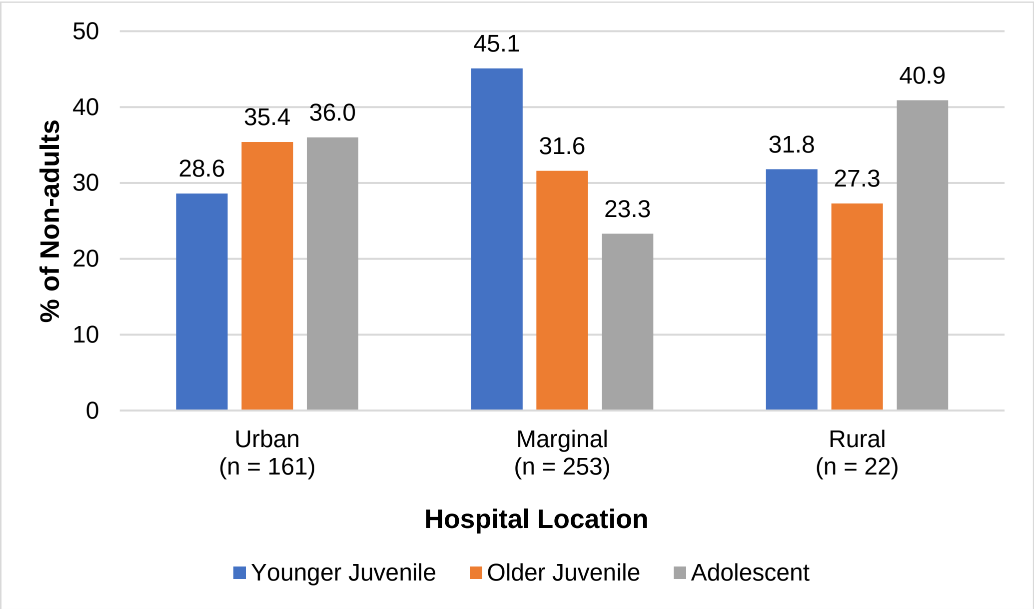


Figure 5.4.6 Distribution of age categories by hospital location in Group B (n = 436).

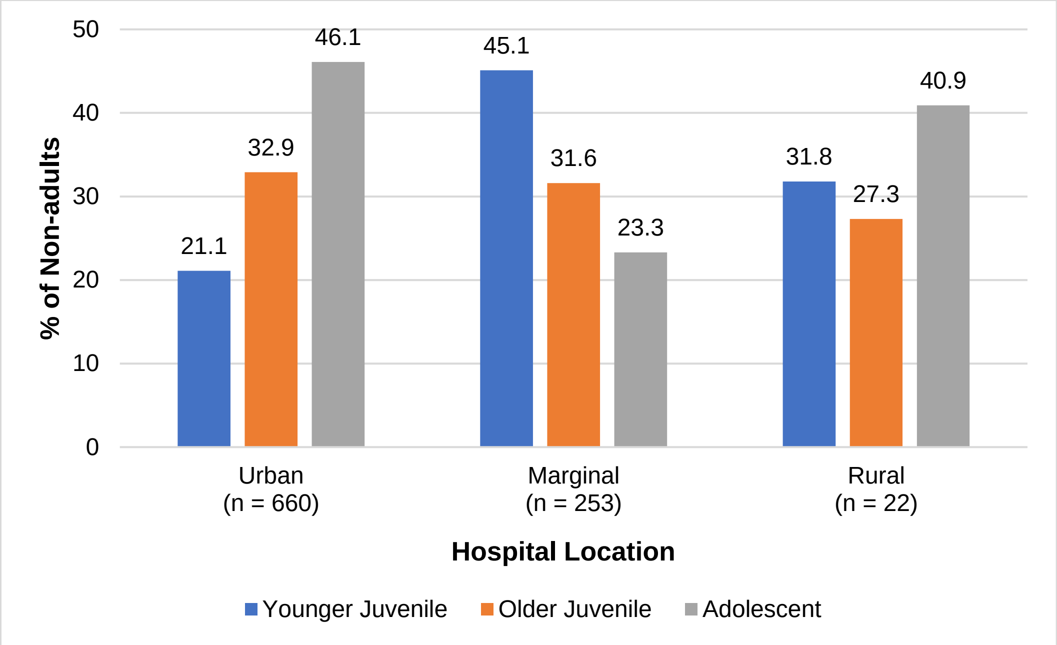


Figure 5.4.7 Distribution of age categories by hospital location in Group C (n = 935).

5.4.5 Age and Hospitals for Pilgrims

Pilgrims were specifically catered for at six of the hospitals from which non-adults have been identified.[2] Table 5.4.7 shows that a greater number of non-adults were recorded from hospitals that are known to have catered for pilgrims in Groups A and C, whilst in Group B, a higher number of non-adults were recorded from hospitals that did not specifically cater for pilgrims. Figure 5.4.8 illustrates that in each group, a higher proportion of adolescents were identified in hospitals for pilgrims, whilst younger and older juveniles were identified in higher proportions at sites which did not cater for pilgrims. A statistically significant difference ($p = <0.01$) was found in all three groups: Group A (χ^2 (2, n = 1,506) = 129.244, p = 0.000), Group B (χ^2 (2, n = 436) = 16.149, p = 0.000), and Group C (χ^2 (2, n = 935) = 61.455, p = 0.000).

[2] Sites which catered for pilgrims: 16. St Mary Magdalene, Winchester; 19. St Peter, St Paul and Thomas the Martyr, Maidstone; 22. St Mary, Ospringe; 26. St Mary Spital, London; 34. St John the Baptist, Lichfield; and 39. St Mary Magdalen, Bidlington.

Table 5.4.7 Numbers and percentages of non-adults at hospitals which catered for and did not cater for pilgrims.

Age Category	Group A				Group B				Group C			
	For Pilgrims		Not for Pilgrims		For Pilgrims		Not for Pilgrims		For Pilgrims		Not for Pilgrims	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Younger Juveniles	149	9.9	158	10.5	9	2.1	158	36.2	102	10.9	158	16.9
Older Juveniles	370	24.6	134	8.9	9	2.1	134	30.7	169	18.1	134	14.3
Adolescents	585	38.8	110	7.3	16	3.7	110	25.2	262	28.0	110	11.8
Total	**1,104**	**73.3**	**402**	**26.7**	**34**	**7.9**	**402**	**92.1**	**533**	**57.0**	**402**	**43.0**

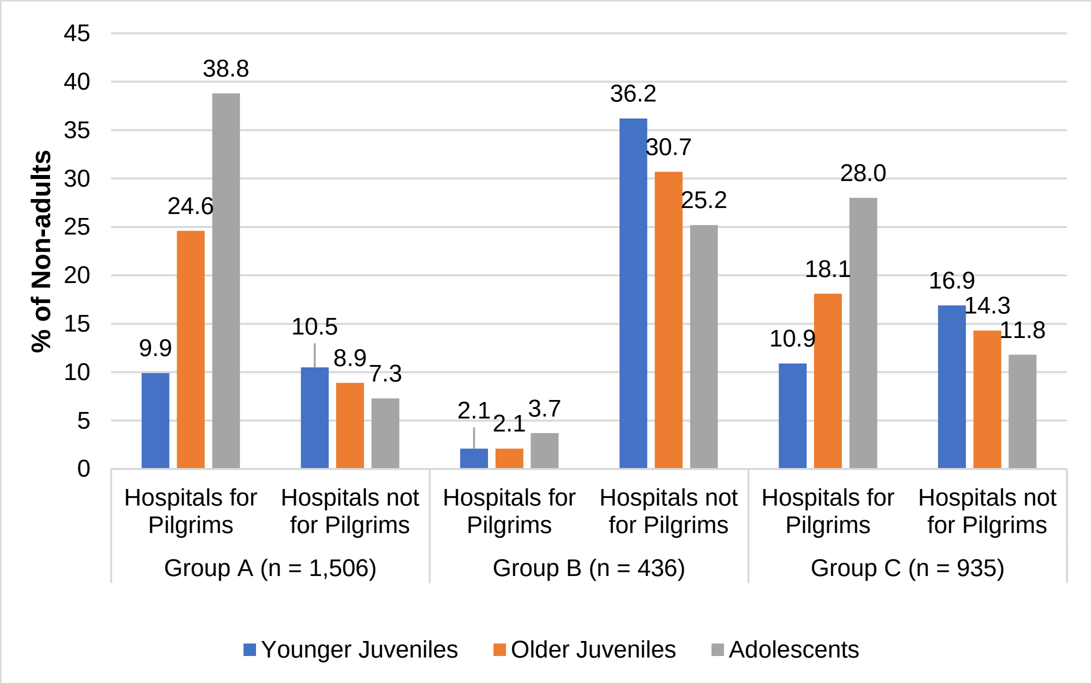


Figure 5.4.8 Percentages of non-adults by hospitals that catered for or did not cater for pilgrims.

5.4.6 Age and Phasing of Cemeteries

Most hospital cemetery sites (n = 22, 81.5%) were not divided into phases by the excavators, often due to the small size of the excavation or a lack of grave goods to date burials. Five hospital cemeteries were divided into phases.[3] Different cemetery

[3] Sites where cemeteries were phased: 4. St John the Evangelist, Cambridge; 6. St Leonard's, Peterborough; 11. Crouched Friars, Colchester; 26. St Mary Spital, London; and 40. St James and St Mary Magdalene, Chichester.

phases and calendar dates were used at each of the five sites; therefore, it was not possible to compare the data, and each cemetery was analysed individually. Calendar dates were attributed to phases at four of these sites, namely at St John, Cambridge (MNI of non-adults = 62), which was divided into five phases, St Leonard, Peterborough (n = 7), and Crouched Friars, Essex (n = 16), both have two phases, while St Mary Spital, London (n = 1,027), has four phases. The non-adults reported from the initial excavation at the St Mary Spital site have not been included in this specific analysis as this area of the cemetery was dated to between A.D. 1235 and 1280 (Thomas *et al*., 1997), which overlaps the phases given in the later excavations by Connell *et al*. (2012).

The burials from St James and St Mary Magdalene, Chichester (n = 104), were placed into three chronological phases, based on an interpretation of the cemetery expansion (Magilton *et al*., 2008). Most non-adult burials (n = 93, 89.4%) at this site were located in Phase 1 of the cemetery. The number of individuals from St Leonard, Peterborough, and Crouched Friars, Essex, were too low to be statistically tested, and consequently these three sites were not statistically analysed.

The data from St John, Cambridge were tested using the chi-square test. No younger juveniles were identified at this site. Of the 61 non-adults recovered from the cemetery, 60 (98.4%) were associated with definitive phases of the cemetery (Figure 5.4.9). The chi-square result (χ^2 (4, n = 60) = 1.369, p = 0.850) is statistically insignificant (p = <0.05), illustrating that there is no significant difference in the proportion of non-adults by age category between cemetery phases.

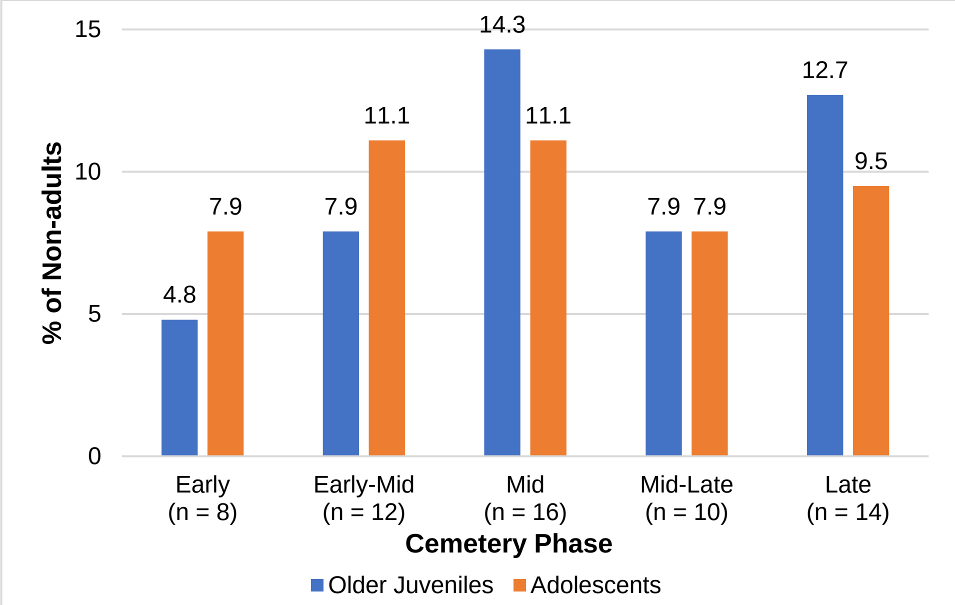


Figure 5.4.9 Older juveniles and adolescents identified from the different phases of the cemetery of St John, Cambridge.

At St Mary Spital, London, in the final phase of the cemetery the proportion of younger juveniles is greater, whilst older juveniles and adolescents form a lower proportion than they did in earlier phases (Figure 5.4.10). The difference between the non-adult population by age in category in the final phase and earlier phases was statistically significant (χ^2 (12, n = 1028) = 91.368, p = 0.000) (p = <0.01). Possible reasons for this difference are considered in the Discussion Chapter (Section 6.2.3).

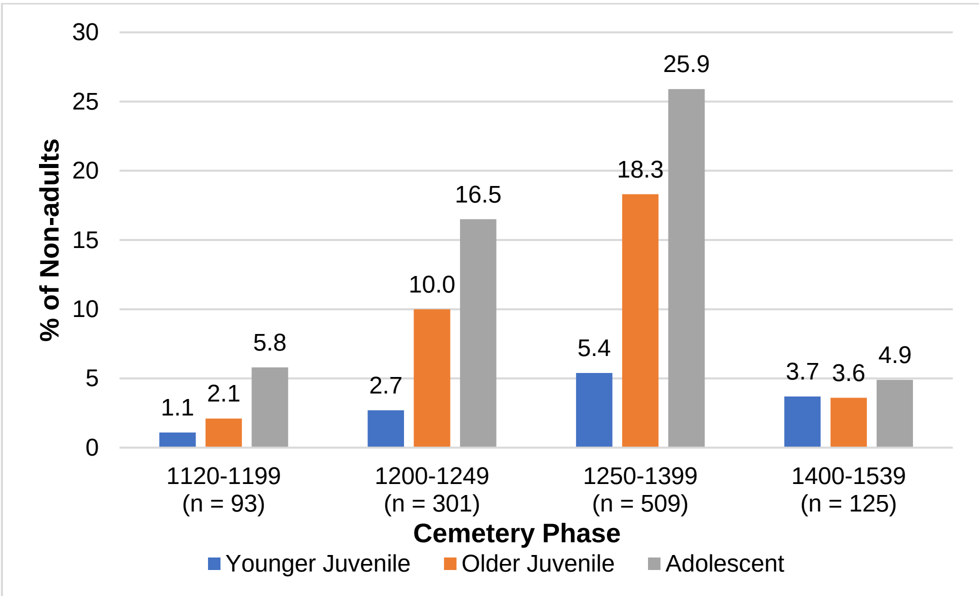


Figure 5.4.10 Age categories and phases of the cemetery of St Mary Spital, London.

5.4.7 Age and Hospitals Dated to Pre and Post the Black Death

Three hospitals were identified which were operational solely before or after the Black Death plague of A.D. 1348-1349. In total, 11 non-adults were recorded at St Margaret, Huntingdon (A.D. 1150-1341), and five non-adults were identified at St Mary Magdalene, Partney (A.D. 1115-1318). Both hospitals were founded and closed prior to the Black Death. St Bartholomew, Bristol (c. A.D. 1400-c.1532), is the only hospital cemetery that was founded after the Black Death. Here, seven non-adults were identified. The number of sites and the data for non-adults from these sites, were too limited to permit statistical analysis.

5.4.8 Summary

In Groups A and C, the highest proportion of non-adults were adolescents, with lower numbers of older juveniles, and younger juveniles comprising the lowest proportion. In contrast, when the St Mary Spital, London, data were removed in Group B, the reverse trend is seen. Younger juveniles form the highest proportion of non-adults, with declining numbers of older juveniles and adolescents. Urban hospitals had higher rates of adolescents, whilst marginal hospitals had higher proportions of younger juveniles. Hospitals which catered for pilgrims also had higher proportions of adolescents than older or younger juveniles.

5.5 Disease

All the diseases recorded in osteology reports utilised for this current research were placed into six categories, namely congenital, metabolic, infectious, joint, miscellaneous, and dental diseases. Each pathology was recorded alongside the numbers of non-adults reported with each of the diseases (Table 5.5.1). The skeletal remains of individuals that were not osteologically analysed beyond demographic data were removed from the following analyses. Thus, the minimum number of individuals in Group A is 1,414, Group B is 381, and Group C is 843. In the current section and in Sections 5.6 and 5.7 below, table rows stating the total number and percentage of non-adults reported with a pathology or trauma are provided. In tables where the frequency of a pathology or trauma are given, total rows are not included as a single non-adult may have exhibited two or more pathologies and therefore the number of pathologies recorded can be greater than the number of non-adults.

Table 5.5.1 Numbers and percentages of non-adults with pathologies in the six categories.

	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
Category	**Number**	**%**	**Number**	**%**	**Number**	**%**
Congenital Disease	40	2.8	18	4.7	27	3.2
Metabolic Disease	513	36.3	88	23.1	257	30.5
Infectious Disease	283	20.0	93	24.4	181	21.5
Joint Disease	123	8.7	13	3.4	68	8.1
Miscellaneous Conditions	31	2.2	25	6.6	28	3.3
Dental Conditions	871	61.6	99	26.0	420	49.8

Skeletal pathology and dental conditions are initially explored in this section by age category, followed by their distribution by hospital location. Where there was sufficient data and spread of data across categories, chi-square tests were run to assess the null hypotheses and associated questions 4 and 5 (Appendix 3): firstly, that there is no difference in the occurrence of a pathology by age category, and secondly, that there is no difference in the occurrence of a pathology by hospital location.

Figure 5.5.1 illustrates the percentages of non-adults recorded with a pathology, in each of the six categories, in Groups A, B, and C. As shown, rates of congenital and infectious disease, and miscellaneous conditions are higher in Group B. Metabolic disease and dental conditions are notably greater in Group A non-adults, whilst proportions of joint disease are similar in Groups A and C.

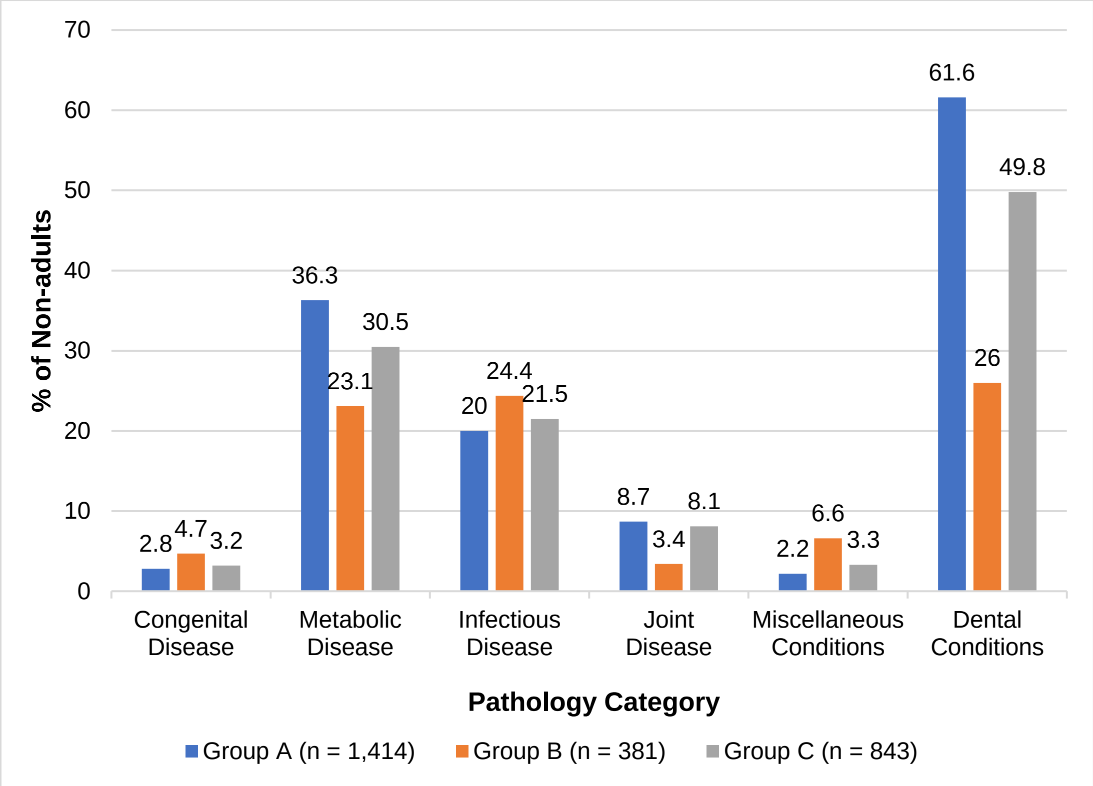


Figure 5.5.1 The proportion of non-adults with pathologies in each of the six categories in Groups A, B, and C.

5.5.1 Disease and Age

5.5.1.1 Congenital Disease

The congenital diseases recorded in osteological reports include nine separate conditions (Table 5.5.2). A total of 40 non-adults were reported with a congenital condition, five of whom exhibited two congenital conditions. Consequently, the numbers of recorded conditions stated in Table 5.5.2 is greater than the number of non-adults reported with a congenital condition in Table 5.5.3. The most frequently reported conditions were congenital fusion, cranial anomalies, and spinal disorders.

Table 5.5.2 Numbers and percentages of congenital conditions reported in Groups A, B, and C.

Congenital Condition	Group A (n = 1,414) Number	%	Group B (n = 381) Number	%	Group C (n = 843) Number	%
Congenital Fusion	9	0.6	6	1.6	8	0.9
Congenital Syphilis	3	0.2	1	0.3	3	0.4
Cranial Anomalies	9	0.6	3	0.8	3	0.4
Developmental Dysplasia of the Hip	2	0.1	0	0.0	1	0.1
Klippel-Fell Syndrome	1	0.1	1	0.3	1	0.1
Other Spinal Disorders	8	0.6	4	1.0	7	0.8
Scoliosis	3	0.2	1	0.3	2	0.2
Spina Bifida Occulta	5	0.4	5	1.3	5	0.6
Spondylolysis	6	0.4	1	0.3	2	0.2

As shown in Table 5.5.3 and Figure 5.5.2, the rate of recorded congenital conditions increases with age. The differences between younger juveniles and adolescents were statistically significant ($p = <0.01$) in all three groups: Group A (χ^2 (2, n = 1,414) = 24.886, p = 0.000), Group B (χ^2 (2, n = 381) = 18.567, p = 0.000), and Group C (χ^2 (2, n = 843) = 16.183, p = 0.000). The proportion of non-adults reported with a congenital condition was higher in all age categories in Group B than in Groups A or C. Group B had the greatest range of values at 2.4%.

Table 5.5.3 The number and percentage of non-adults reported with a congenital condition by age category.

Age Category	Group A (n = 1,414) Number	%	Group B (n = 381) Number	%	Group C (n = 843) Number	%
Younger Juvenile	2	0.1	2	0.5	2	0.2
Older Juvenile	8	0.6	5	1.3	8	0.9
Adolescent	30	2.1	11	2.9	17	2.0
Total	**40**	**2.8**	**18**	**4.7**	**27**	**3.2**

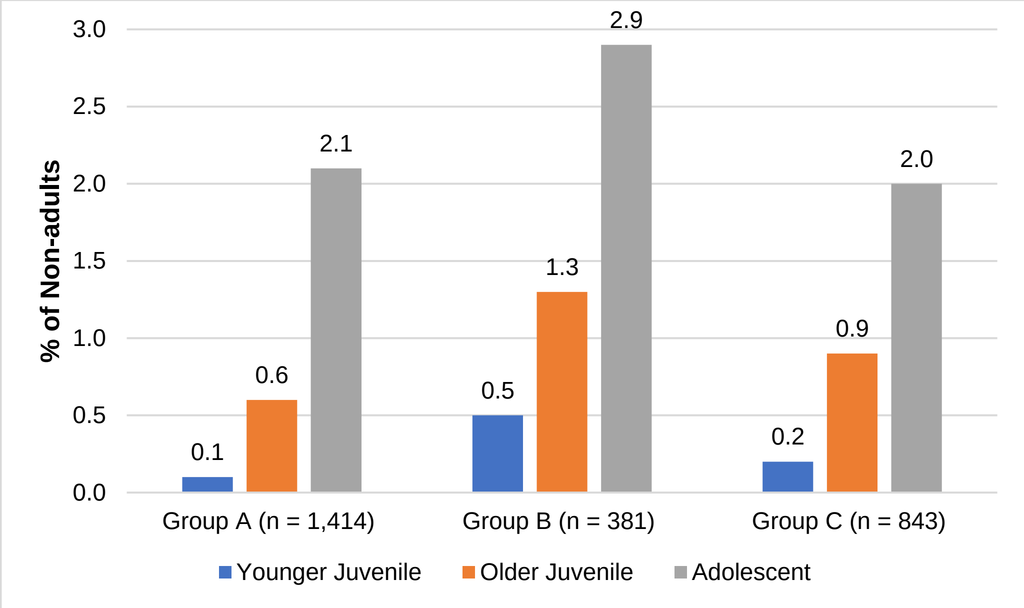


Figure 5.5.2 The percentage of non-adults reported with a congenital condition by age category in Groups A, B, and C.

5.5.1.2 Metabolic Disease

The metabolic conditions observed on non-adults are shown in Table 5.5.4. The most frequently recorded metabolic condition in non-adults from medieval hospitals was cribra orbitalia. Porotic hyperostosis was only reported for non-adults from St Mary Spital, London, which may reflect differences in osteological recording practices rather than an absence of the condition in non-adults from other hospital sites. Vitamin D deficiency rickets and Vitamin C deficiency scurvy were each identified on just over 1% of the total non-adult population.

Table 5.5.4 Numbers and percentages of metabolic conditions reported in Groups A, B, and C.

	Group A (n = 1,414)		**Group B (n = 381)**		**Group C (n = 843)**	
Metabolic Condition	Number	%	Number	%	Number	%
Cribra orbitalia	457	32.3	74	19.4	218	25.9
Kidney stone	1	0.1	0	0.0	1	0.1
Porotic hyperostosis	98	6.9	0	0.0	40	4.7
Rickets (Vitamin D deficiency)	16	1.1	11	2.9	14	1.7
Scurvy (Vitamin C deficiency)	15	1.1	9	2.4	11	1.3

Table 5.5.5 and Figure 5.5.3 show that in Groups A and C the proportion of non-adults exhibiting a metabolic condition increased with age. In Group B, however, younger juveniles were reported with a higher rate of metabolic conditions than older juveniles or adolescents. The differences between the groups may be influenced by the reporting of porotic hyperostosis only from St Mary Spital, as 74 of the 98 (75.5%) non-adults with this condition were adolescents (Figure 5.5.4).

Table 5.5.5 Numbers and percentages of non-adults reported with a metabolic condition by age category.

	Group A (n = 1,414)		**Group B (n = 381)**		**Group C (n = 843)**	
Age Category	Number	%	Number	%	Number	%
Younger Juvenile	59	4.2	38	10.0	54	6.4
Older Juvenile	177	12.5	22	5.8	74	8.8
Adolescent	277	19.6	28	7.3	129	15.3
Total	**513**	**36.3**	**88**	**23.1**	**257**	**30.5**

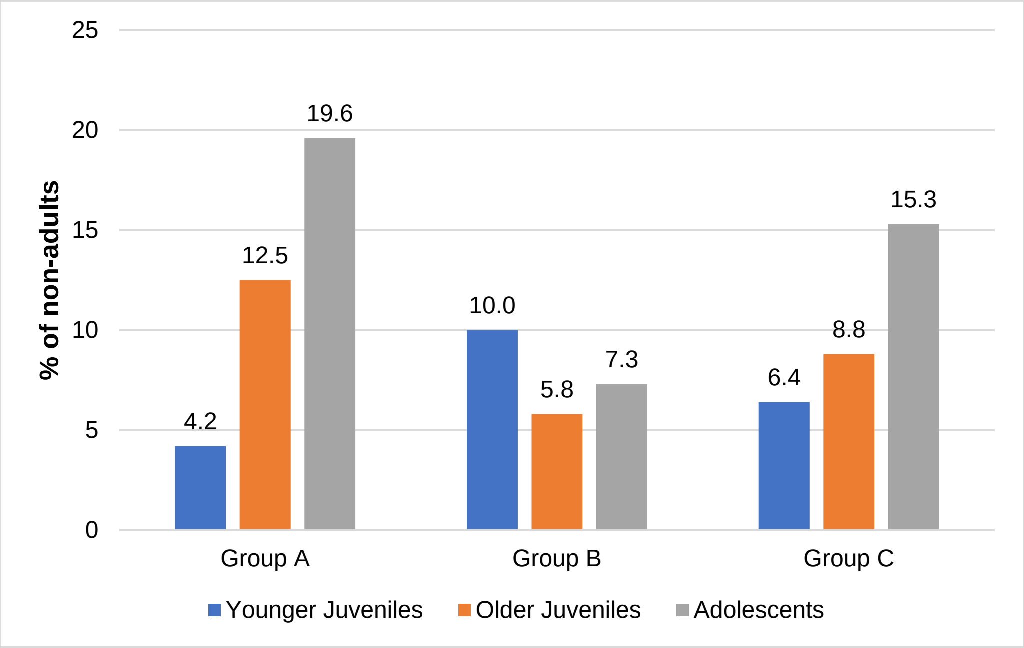


Figure 5.5.3 The percentage of non-adults recorded with a metabolic disease in Groups A, B and C.

Figure 5.5.4 illustrates the differences in the proportions of each metabolic condition reported within Groups A, B, and C by age category. Only a single younger juvenile was identified with a kidney stone. In Groups A and C, cribra orbitalia was reported for a lower proportion of younger juveniles (n = 46 and n = 41 respectively) than older juveniles (n = 164 and n = 68 respectively) or adolescents (n = 247 and n = 109, respectively). These results were statistically significant (p = <0.01) for both groups: Group A (χ^2 (2, n = 1,414) = 49.725, p = 0.000) and Group C (χ^2 (2, n = 843) = 21.207, p = 0.000). In Group B, the results were statistically insignificant at the p = <0.05 value (χ^2 (2, n = 381) = 4.449, p = 0.108) as cribra orbitalia was identified in a similar number and proportion of younger juveniles (n = 28) and adolescents (n = 27), although in fewer older juveniles (n = 19).

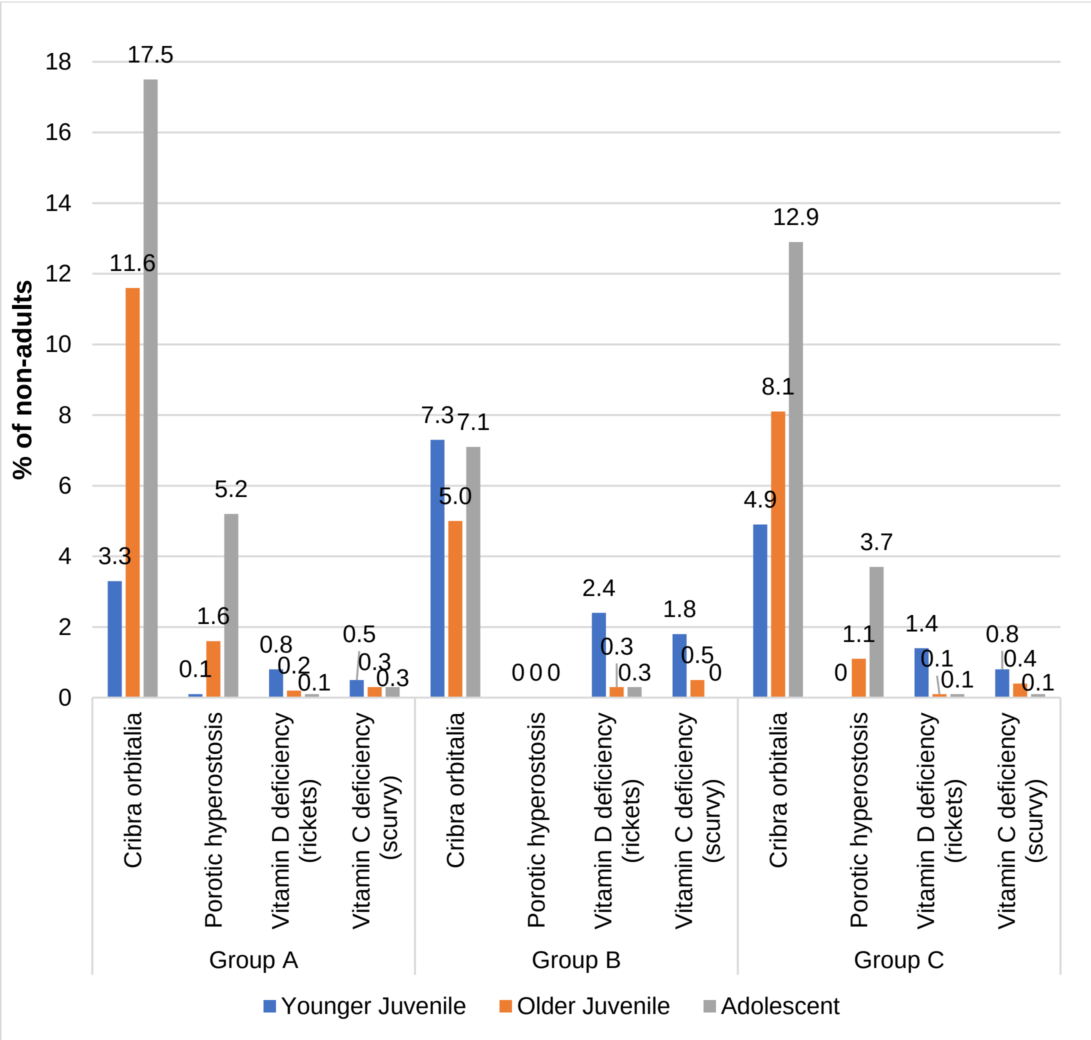


Figure 5.5.4 The percentage of metabolic conditions reported in non-adults by age category.

A total of 98 non-adults exhibited porotic hyperostosis, a single younger juvenile, 23 older juveniles, and 74 adolescents. The chi-square result (χ^2 (2, n = 1033) = 25.738, p = 0.000) demonstrates a statistically significant (p = <0.01) difference between these age groups. Conversely, Vitamin D deficiency (rickets) and Vitamin

C deficiency (scurvy) were identified in greater numbers of younger juveniles (rickets 12/16; scurvy 7/15) than older juveniles (rickets 3/16; scurvy 4/15) or adolescents (rickets 1/16; scurvy 4/15). Chi-square tests showed that the differences in the presence of rickets across age categories was statistically significant (p = <0.01) in Group A (χ^2 (2, n = 1,414) = 29.016, p = 0.000).

5.4.1.3 Infectious Disease

A total of 283 (20.0%) individuals were recorded in osteological reports as displaying evidence of an infectious disease. Overall, six specific infectious diseases were recorded (Table 5.5.6), two respiratory infections (Table 5.5.7), and eight non-specific infectious diseases (Table 5.5.8). The quantity and spread of data for four pathologies, namely leprosy, sinusitis, tuberculosis, and endocranial lesions were sufficient to be tested using a Pearson's chi-square test, the results of which are presented below. Evidence of subperiosteal new bone formation, was reported for individuals where evidence of infection was apparent on the bone but could not be attributed to a distinct infection. The location of subperiosteal new bone formation on the skeleton and its appearance as woven or lamellar bone were also recorded (Tables 5.5.9 and 5.5.10) and statistical analyses conducted on these data.

Table 5.5.6 Numbers and percentages of infectious disease reported in Groups A, B, and C.

	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
Infectious Disease	**Number**	**%**	**Number**	**%**	**Number**	**%**
Bowel Infection	2	0.1	0	0.0	0	0.0
Fungal Infection	1	0.1	1	0.3	1	0.1
Leprosy	24	1.7	24	6.3	24	2.8
Rhinitis	2	0.1	2	0.5	2	0.2
Sinusitis	18	1.3	15	3.9	16	1.2
Treponemal Disease	4	0.3	1	0.3	4	0.5

Table 5.5.7 Numbers and percentages of respiratory infections reported in Groups A, B, and C.

	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
Respiratory Infection	**Number**	**%**	**Number**	**%**	**Number**	**%**
Rib Lesions	4	0.3	4	1	4	0.5
Tuberculosis	33	2.3	13	3.4	22	2.6

Table 5.5.8 Numbers and percentages of non-specific infections reported in Groups A, B, and C.

Non-specific Infection	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
	Number	**%**	**Number**	**%**	**Number**	**%**
Endocranial Lesions	41	2.9	7	1.8	21	2.5
Mastoiditis	1	0.1	1	0.3	1	0.1
Osteitis	7	0.5	2	0.5	5	0.6
Osteolytic Lesions	2	0.1	2	0.5	2	0.2
Osteomyelitis	7	0.5	2	0.5	4	0.5
Otitis Media	2	0.1	1	0.3	1	0.1
Otosclerosis	2	0.1	2	0.5	2	0.2
Subperiosteal New Bone Formation	196	13.9	62	16.3	126	14.9

Table 5.5.9 Numbers and percentages of the location of subperiosteal new bone formation reported in Groups A, B, and C.

Location of subperiosteal new bone formation	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
	Number	**%**	**Number**	**%**	**Number**	**%**
Skull	26	1.8	11	2.9	15	1.8
Axial (ribs and spine)	55	3.9	8	2.1	32	3.8
Upper long bone	20	1.4	6	1.6	16	1.2
Lower long bone	111	7.9	37	9.7	72	8.5

Table 5.5.10 Numbers and percentages of the appearance of subperiosteal new bone formation reported in Groups A, B, and C.

Appearance of subperiosteal new bone formation	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
	Number	%	Number	%	Number	%
Woven bone	128	9.1	26	6.8	75	8.9
Lamellar bone	46	3.3	12	3.1	26	3.1
Woven and lamellar bone	14	1.0	6	1.6	10	1.2

When the data for infectious disease were combined, the observed occurrence of infectious diseases increased with age in all three groups (Table 5.5.11 and Figure 5.5.5). The only difference to this trend was in Group B, where a slightly greater number of younger juveniles than older juveniles were reported with an infectious disease. The disparity between lower numbers of younger and older juveniles and the higher numbers of adolescents who exhibited evidence of an infectious disease was statistically significant (p = <0.01) in Groups A (χ^2 (2, n = 1,414) = 44.626, p = 0.000), B (χ^2 (2, n = 381) = 44.013, p = 0.000), and C (χ^2 (2, n = 843) = 47.915, p = 0.000).

Table 5.5.11 Numbers and percentages of non-adults recorded with an infectious disease by age category in Groups A, B, and C.

Age Category	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
	Number	%	Number	%	Number	%
Younger Juvenile	30	2.1	23	6.0	28	3.3
Older Juvenile	77	5.4	22	5.8	48	5.7
Adolescent	176	12.4	48	12.6	105	12.5
Total	**283**	**20.0**	**93**	**24.4**	**181**	**21.5**

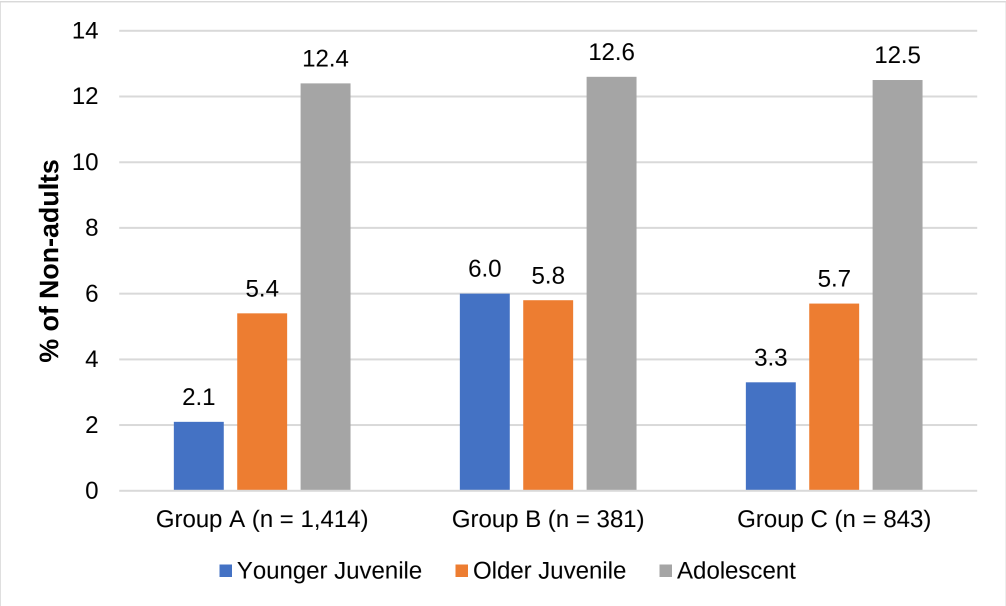


Figure 5.5.5 The percentage of non-adults recorded with an infectious disease by age category in Groups A, B, and C.

In total, 24 non-adults from medieval hospital sites displayed evidence of leprosy. As no individuals from St Mary Spital, London, were reported with leprosy, only Group B was analysed. As shown in Figure 5.5.6, the majority of non-adults exhibiting indicators of leprosy were adolescents. The chi-square test demonstrates that the difference in the presence of leprosy by age category is statistically significant (χ^2 (2, n = 381) = 36.079, p = 0.000) at the p = <0.01 value.

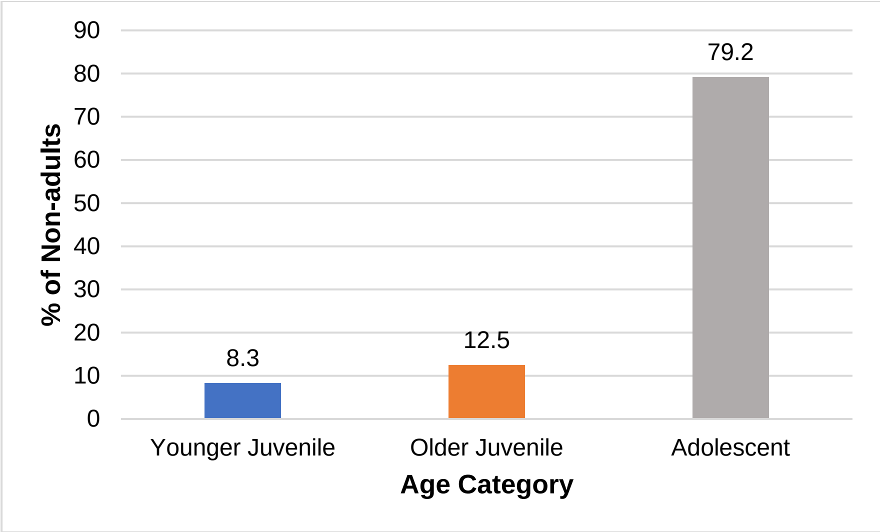


Figure 5.5.6 Percentages of non-adults recorded with leprosy by age category in Group B (n = 24).

Evidence of sinusitis was observed in 18 non-adults. Figure 5.5.7 illustrates that in each group, around one quarter of non-adults with sinusitis were younger juveniles, whilst the proportions of older juveniles was lower in each instance. Over half of those recorded with sinusitis were adolescents. However, the difference in the occurrence of sinusitis by age category was not statistically significant in Groups A (χ^2 (2, n = 1,414) = 2.400, p = 0.301) or C (χ^2 (2, n = 843) = 2.248, p = 0.325). There were insufficient data in Group B (n = 15) to test using chi-square.

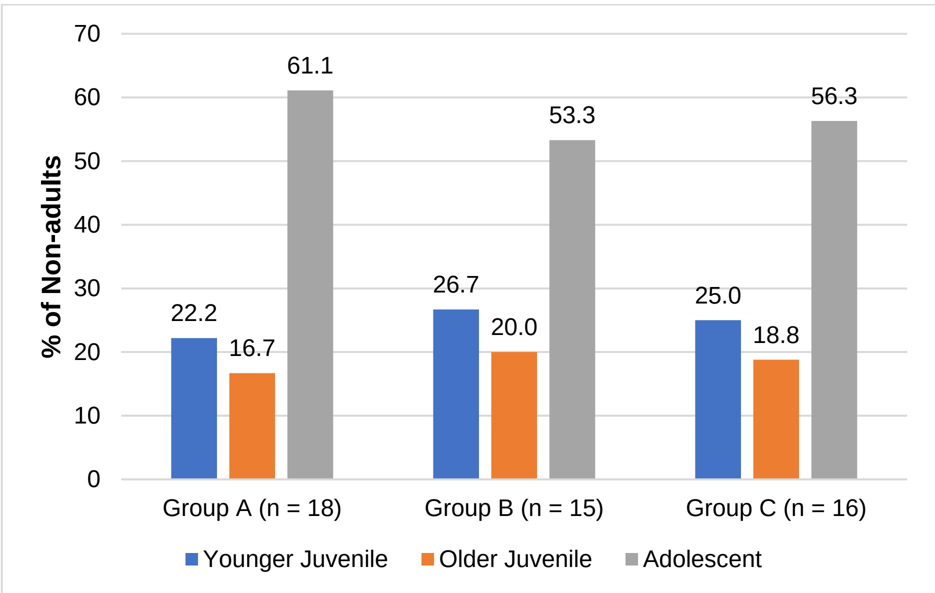


Figure 5.5.7 Percentages of non-adults recorded with sinusitis by age category in Groups A, B, and C.

Tuberculosis (TB) was identified in 33 non-adults. In each group only a small proportion of younger juveniles exhibited evidence of the condition, although the figure is higher in Group B than Groups A or C (Figure 5.5.8). Older juveniles account for nearly one third of cases, whilst most non-adults reported with TB were adolescents. In Group B, there was an insufficient quantity of data to allow statistical analysis. Yet, chi-square results show these differences between younger juveniles and adolescents were statistically significant ($p = <0.05$) in Groups A (χ^2 (2, n = 1,414) = 8.422, p = 0.015) and C (χ^2 (2, n = 843) = 8.399, p = 0.015).

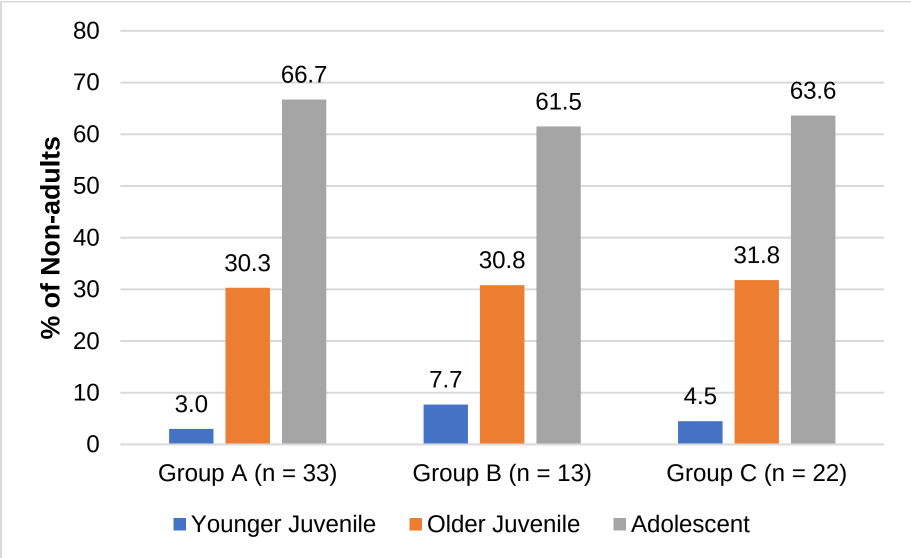


Figure 5.5.8 Percentages of non-adults recorded with tuberculosis by age category in Groups A, B, and C.

Figure 5.5.9 shows the distribution of endocranial lesions recorded by age category. The patterns are different in Group A where the rates increase with age, compared to Groups B and C, in which a comparatively greater proportion of younger juveniles were recorded with endocranial lesions than in Group A, and a higher proportion of older juveniles than adolescents were reported with this pathology. This may reflect differences in the occurrence of the condition in non-adults identified in the mass burials at St Mary Spital. The data in Group B was too small to permit statistical analysis. The chi-square test results from Group A (χ^2 (2, n = 1,414) = 3.152, p = 0.207) and Group C (χ^2 (2, n = 843) = 1.894, p = 0.388) indicate that the differences in the presence of endocranial lesions by age category were statistically insignificant ($p = 0.05$).

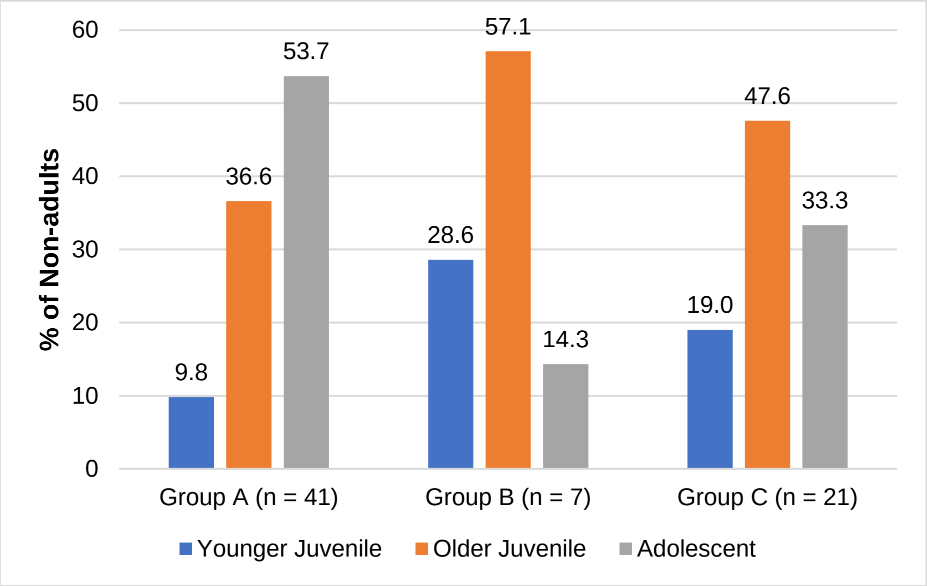


Figure 5.5.9 Percentages of non-adults recorded with endocranial lesions by age category in Groups A, B, and C.

A total of 196 non-adults from hospital sites exhibited subperiosteal new bone formation on their skeletal remains. As illustrated in Figure 5.5.10, in Groups A and C the proportions of non-adults recorded with this pathology increase with age. In Group B this pattern is slightly different as an equal proportion of younger juveniles and older juveniles were reported with subperiosteal new bone formation. In all three groups the chi-square results (Group A (χ^2 (2, n = 1,414) = 43.048, p = 0.000), Group B (χ^2 (2, n = 381) = 45.450, p = 0.000), and Group C (χ^2 (2, n = 843) = 47.842, p = 0.000) for differences in the presence of subperiosteal new bone formation by age category were statistically significant ($p = <0.01$) between younger juveniles and adolescents.

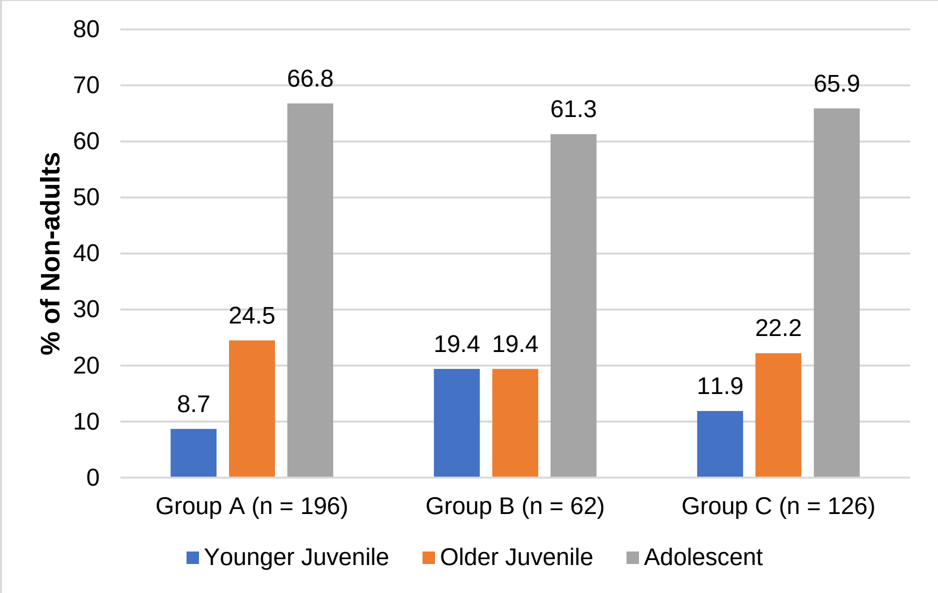
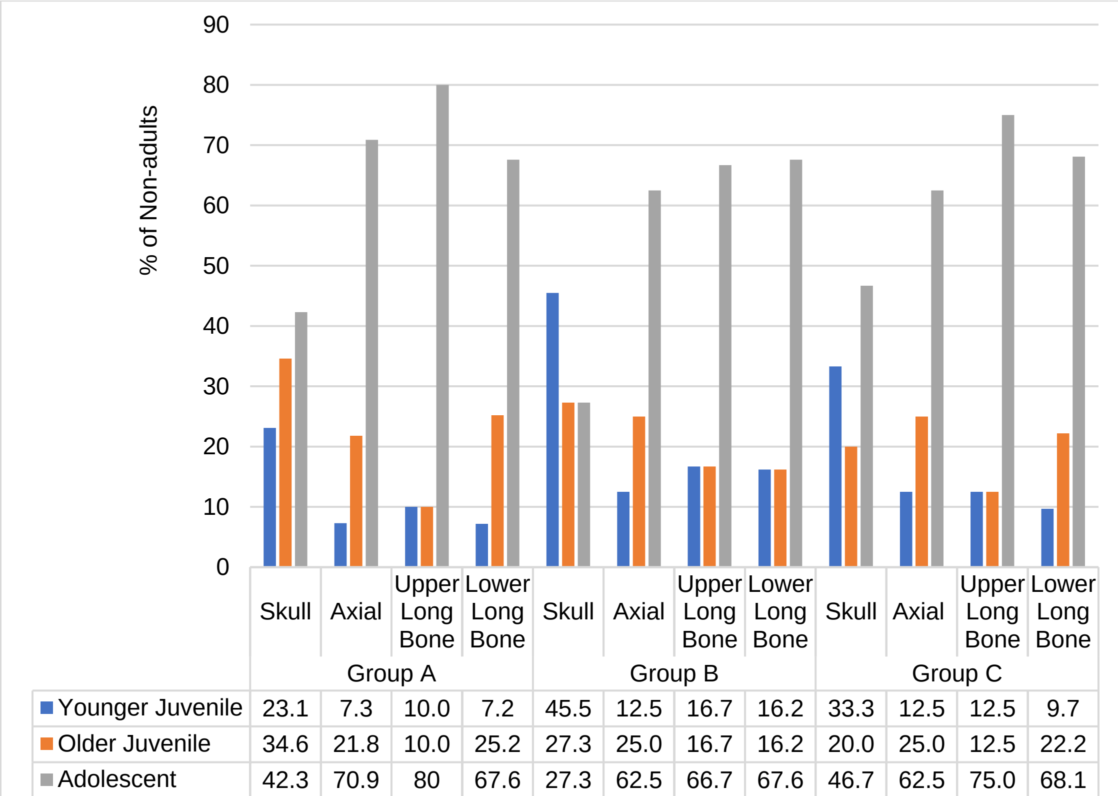


Figure 5.5.10 Percentages of non-adults recorded with subperiosteal new bone formation by age category in Groups A, B, and C.

Figure 5.5.11 shows the different regions of the skeleton (skull, axial (spine and ribs only), and long bones) where subperiosteal new bone formation was recorded in osteological reports. Whilst overall, the presence of subperiosteal new bone formation increases with age, in Group B, a higher proportion of younger juveniles than adolescents exhibited subperiosteal new bone formation on the skull. In all groups the proportions of younger juveniles and older juveniles reported with subperiosteal new bone formation on the upper long bones are equal, and this is also true for the lower long bones in Group B.

Where there was a sufficient quantity and spread of data, chi-square tests were conducted. The results show that the difference in the presence of subperiosteal new bone formation on the axial bones between younger and older juveniles, and adolescents was statistically significant (p = <0.05) in Groups A (χ^2 (2, n = 1,414) = 15.057, p = 0.01) and C (χ^2 (2, n = 843) = 8.575, p = 0.014). A similar statistically significant difference (p = <0.05) was identified in Group A (χ^2 (2, n = 1,414) = 9.538, p = 0.008) and Group C (χ^2 (2, n = 843) = 9.008, p = 0.011) between these age groups and the occurrence of subperiosteal new bone formation on the upper long bones. In all three groups the reporting of subperiosteal new bone formation on the lower long bones was statistically significant (p = <0.01): Group A (χ^2 (2, n = 1,414) = 25.361, p = 0.000), Group B (χ^2 (2, n = 381) = 34.961, p = 0.000), and Group C (χ^2

(2, n = 843) = 30.103, p = 0.000). In Groups A and C this difference was observed between younger juveniles and adolescents, whilst in Group B a difference was found between younger and older juveniles, and adolescents.



	Group A				Group B				Group C			
	Skull	Axial	Upper Long Bone	Lower Long Bone	Skull	Axial	Upper Long Bone	Lower Long Bone	Skull	Axial	Upper Long Bone	Lower Long Bone
Younger Juvenile	23.1	7.3	10.0	7.2	45.5	12.5	16.7	16.2	33.3	12.5	12.5	9.7
Older Juvenile	34.6	21.8	10.0	25.2	27.3	25.0	16.7	16.2	20.0	25.0	12.5	22.2
Adolescent	42.3	70.9	80	67.6	27.3	62.5	66.7	67.6	46.7	62.5	75.0	68.1

Figure 5.5.11 Percentages of non-adults recorded with subperiosteal new bone formation by skeletal location and age category in Groups A, B, and C.

The presence of woven bone on skeletal remains indicates an individual died with an active infection, whilst lamellar bone shows the individual had recovered from a particular infection prior to death (Mays, 2010a). A total of 128 non-adults displayed evidence of woven bone whilst 46 individuals exhibited lamellar bone. A further 14 non-adults were found to have both woven and lamellar bone, indicating a recurrent infection.

Figure 5.5.12 illustrates that in Groups A and C, the presence of woven and lamellar bone increase with age. In Group B, however, younger juveniles were reported with higher rates of woven bone, lamellar bone, and both, than older juveniles. In all three groups, the differences between the rates of woven bone reported in younger juveniles and adolescents are statistically significant, and in Group B the difference between older juveniles and adolescents was also statistically significant (p =

<0.01): Group A (χ^2 (2, n = 1,414) = 24.386, p = 0.000), Group B (χ^2 (2, n = 381) = 25.685, p = 0.000), and Group C (χ^2 (2, n = 843) = 21.762, p = 0.000). Similar findings were obtained using chi-square analysis for the reported proportions of lamellar bone by age category, although the data for Group B was too small to conduct analysis. The differences between the smaller proportions of both younger and older juveniles exhibiting lamellar bone and the higher rates of adolescents were statistically significant (p = <0.01) in both Group A (χ^2 (2, n = 1,414) = 18.271, p = 0.000) and Group C (χ^2 (2, n = 843) = 19.958, p = 0.000). The numbers of non-adults recorded with both woven and lamellar bone were too small to conduct statistical tests.

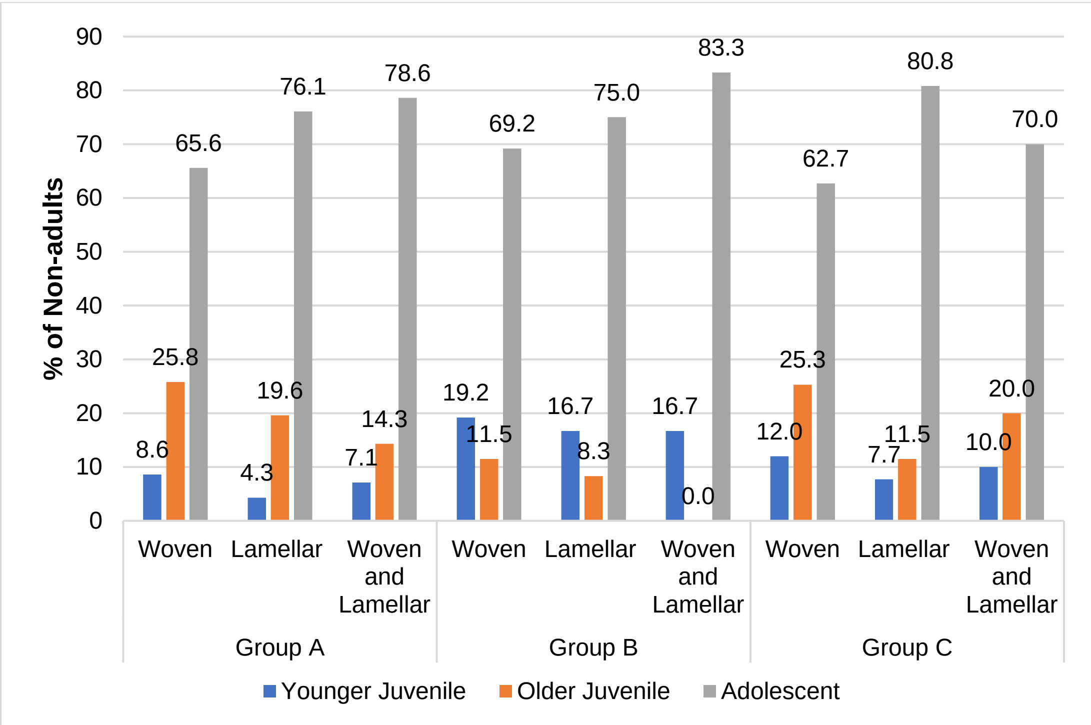


Figure 5.5.12 Percentages of non-adults recorded with subperiosteal new bone formation by appearance and age category in Groups A, B, and C.

5.4.1.4 Joint Disease

Joint disease was recorded in a total of 123 non-adults. There are many different causes of joint disease, including degenerative processes which can be due to trauma, and it is not always possible to ascertain the process which caused the changes to the joint (Mays, 2010). Notably, Schmorl's nodes was the most frequently occurring joint disease, observed in 110 non-adults. A further seven joint diseases were reported, though in a small number of individuals (fewer than eight), which were insufficient for chi-square analyses (Table 5.5.12). In Group B, joint disease was reported in too small a number of individuals to permit statistical testing.

Table 5.5.12 Numbers and percentages of joint disease reported in Groups A, B, and C.

	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
Joint Disease	**Number**	**%**	**Number**	**%**	**Number**	**%**
Ankylosis	7	0.5	4	1.0	5	0.6
Intervertebral Osteochondrosis	1	0.1	1	0.3	1	0.1
Intervertebral Disc Disease	3	0.2	0	0.0	2	0.2
Osteoarthritis	4	0.3	1	0.3	3	0.4
Osteophytes	1	0.1	0	0.0	0	0.0
Schmorl's nodes	110	7.8	8	2.1	58	6.9
Septic Arthritis	2	0.1	2	0.5	2	0.2
Spinal Degenerative Changes	1	0.1	1	0.3	1	0.1

As shown in Table 5.5.13, a single younger juvenile was reported with a joint disease (ankylosis), whilst the majority of joint diseases were observed on adolescents. This is further illustrated in Figure 5.5.13, where it is shown that Schmorl's nodes were not observed on any younger juveniles and fewer than 3.0% of cases were reported for older juveniles. This difference between the presence of Schmorl's nodes within the age categories in Group A (χ^2 (2, n = 1,414) = 126.507, p = 0.000) and Group C (χ^2 (2, n = 843) = 92.855, p = 0.000) were statistically significant (p = <0.01).

Table 5.5.13 Numbers and percentages of non-adults recorded with a joint disease by age category in Groups A, B, and C.

	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
Age Category	**Number**	**%**	**Number**	**%**	**Number**	**%**
Younger Juvenile	1	0.1	1	0.3	1	0.1
Older Juvenile	5	0.4	1	0.3	3	0.4
Adolescent	117	8.3	11	2.9	64	7.6
Total	**123**	**8.7**	**13**	**3.4**	**68**	**8.1**

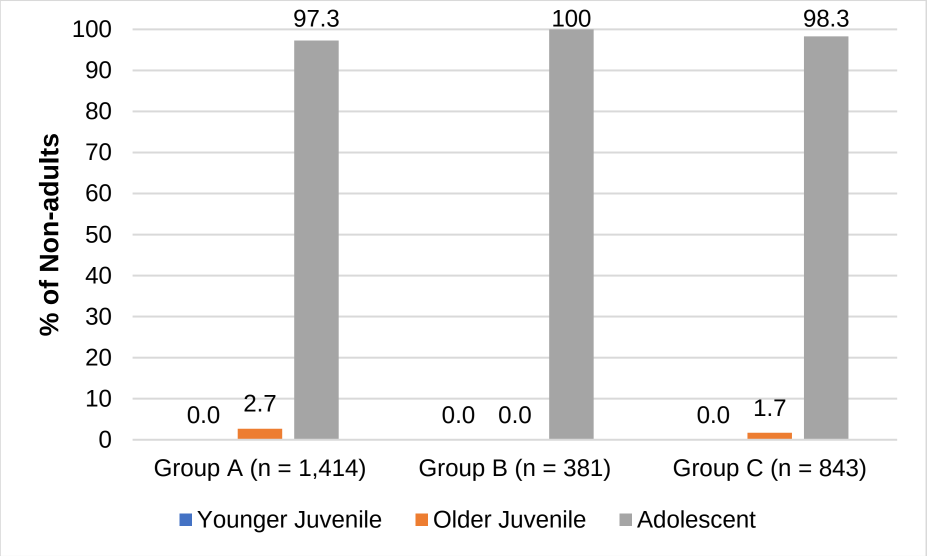


Figure 5.5.13 Percentages of non-adults recorded with Schmorl's nodes in Groups A, B, and C.

5.4.1.5 Miscellaneous Conditions

Miscellaneous conditions were recorded for 31 of the 1,414 non-adults reported from medieval hospital sites for whom pathology data was available. As seen in Table 5.5.14, six of the seven conditions were reported in three or fewer non-adults. Age discrepancy, that is a disparity in the estimated age of an individual, between calculations based on dental eruption and those based on long bone length, were reported for 22 individuals. This condition was recorded in sufficient numbers of non-adults to perform chi-square tests.

Table 5.5.14 Numbers and percentages of miscellaneous conditions reported in Groups A, B, and C.

Miscellaneous Condition	**Group A (n = 1,414)**		**Group B (n = 381)**		**Group C (n = 843)**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Age Discrepancy	22	1.6	22	5.8	22	2.6
Bone Cysts	1	0.1	0	0.0	1	0.1
Chondroma	1	0.1	0	0.0	0	0.0
Neoplastic Disorder	1	0.1	1	0.3	1	0.1
Osteochondroma	3	0.2	0	0.0	2	0.2
Osteoid Osteoma	1	0.1	0	0.0	0	0.0
Torticolis	1	0.1	1	0.3	1	0.1

The proportions of non-adults reported with a miscellaneous condition are relatively similar for younger juveniles and adolescents in Groups B and C, although higher for adolescents in Group A. Notably, a smaller proportion of older juveniles were observed to have a miscellaneous condition (Table 5.5.15). All of the 10 younger juveniles recorded with a miscellaneous condition were reported with an age discrepancy, as were three older juveniles and nine adolescents. These individuals were recorded at five hospital sites,[4] with the majority (n = 17, 77.3%) from a single site, namely St Mary Magdalene, Winchester. As this condition was not recorded for any non-adults at St Mary Spital, only Group B was tested using chi-square. The difference in the occurrence of age discrepancy by age category (χ^2 (2, n = 381) = 3.949, p = 0.139) was statistically insignificant (p = <0.05).

Table 5.5.15 Numbers and percentages of non-adults recorded with a miscellaneous condition by age category in Groups A, B, and C.

Age Category	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
	Number	%	Number	%	Number	%
Younger Juvenile	10	0.7	10	2.6	10	1.2
Older Juvenile	5	0.4	4	1.0	5	0.6
Adolescent	16	1.1	11	2.9	13	1.5
Total	**31**	**2.2**	**25**	**6.6**	**28**	**3.3**

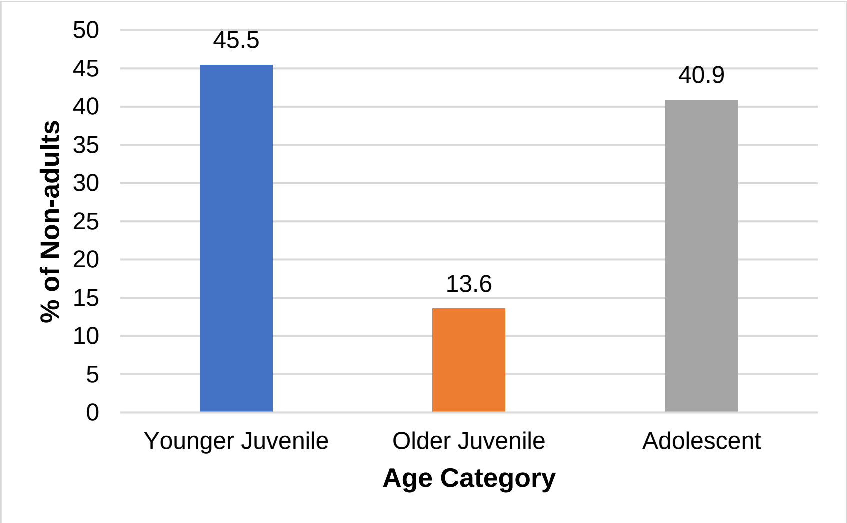


Figure 5.5.14 Percentages of non-adults recorded with an age discrepancy in Group B (n = 22).

[4] Sites from which age discrepancy was reported: 8. St Mary, Castleton; 16. St Mary Magdalene, Winchester; 18. St James, Berkhamsted; 19. St Peter, St Paul and St Thomas the Martyr, Maidstone; and 36. St Peter's, Bury St Edmunds.

5.4.1.6 Dental Conditions

Overall, 964 (68.2%) individuals from a total of 1,414 non-adults had teeth present for analysis (Table 5.5.16). Consequently, only these 964 individuals are considered in the following analyses on dental disease. Additionally, whilst dental enamel hypoplasia (DEH) is a stress indicator rather than a dental disease, it is included here as it manifests on dentition.

Table 5.5.16 Numbers and percentages of non-adults recorded with each dental condition in Groups A, B, and C.

	Group A (n = 964)		Group B (n = 192)		Group C (n = 513)	
Dental Condition	**Number**	**%**	**Number**	**%**	**Number**	**%**
Abscess	43	4.5	4	2.1	15	2.9
Calculus	797	82.7	61	31.8	374	72.9
Caries	318	33.0	26	13.5	155	30.2
Dental Anomalies	212	22.0	8	4.2	100	19.5
Dental Enamel Hypoplasia (DEH)	532	55.2	61	31.8	240	46.8
Periodontal Disease	184	19.1	15	7.8	90	17.5

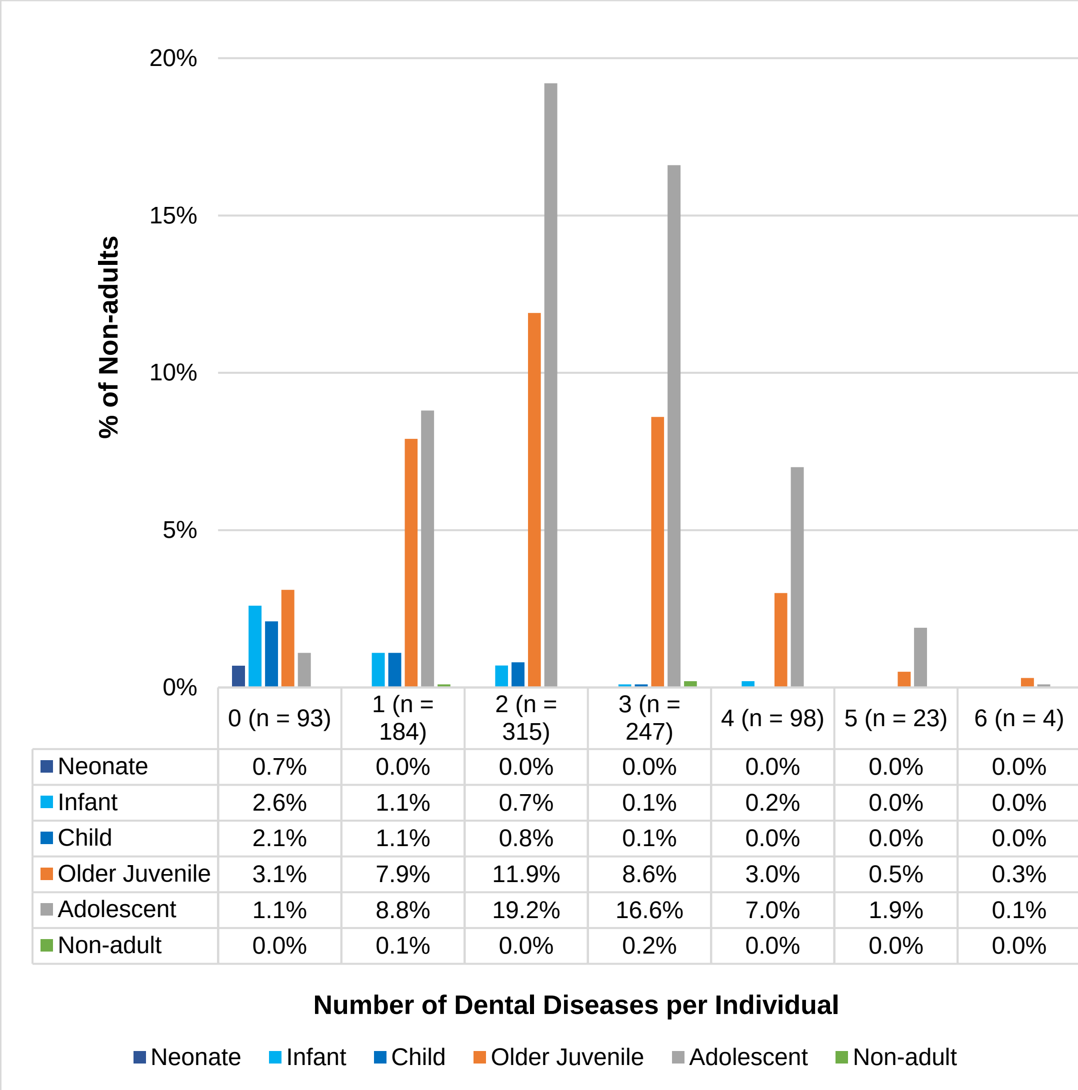
Within the three age categories the proportions of individuals with teeth differed: 31.6% (94/297) of younger juveniles, 73.0% (341/467) of older juveniles, and 81.4% (529/650) of adolescents were found to have surviving teeth. As shown in Table 5.5.17, in all three groups, the reported incidence of dental conditions increases with age.

Table 5.5.17 Numbers and percentages of non-adults recorded with a dental condition by age category in Groups A, B, and C.

	Group A (n = 964)		Group B (n = 192)		Group C (n = 513)	
Age Category	**Number**	**%**	**Number**	**%**	**Number**	**%**
Younger Juvenile	42	4.4	17	8.9	30	5.8
Older Juvenile	311	32.3	38	19.8	156	30.4
Adolescent	518	53.7	44	22.9	234	45.6
Total	**871**	**90.4**	**99**	**51.6**	**420**	**81.9**

Figure 5.5.15 illustrates that the occurrence of multiple dental diseases reported in non-adults also increases with age. Of the 964 individuals with dentition, 93 (9.6%) exhibited no dental disease. Most older juveniles (n = 115) and adolescents (n =

185) with multiple dental conditions exhibited two dental diseases. The numbers of non-adults with three or more dental diseases consistently declines. Only five older juveniles and 18 adolescents were reported with five dental diseases, and three juveniles and one adolescent showed evidence of all six dental conditions.



	0 (n = 93)	1 (n = 184)	2 (n = 315)	3 (n = 247)	4 (n = 98)	5 (n = 23)	6 (n = 4)
Neonate	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Infant	2.6%	1.1%	0.7%	0.1%	0.2%	0.0%	0.0%
Child	2.1%	1.1%	0.8%	0.1%	0.0%	0.0%	0.0%
Older Juvenile	3.1%	7.9%	11.9%	8.6%	3.0%	0.5%	0.3%
Adolescent	1.1%	8.8%	19.2%	16.6%	7.0%	1.9%	0.1%
Non-adult	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%	0.0%

Figure 5.5.15 Percentage of non-adults recorded with multiple dental conditions (n = 964).

Figures 5.5.16 to 5.5.18 show that most dental conditions increased with age, namely abscesses, calculus, dental anomalies, DEH, and periodontal disease. The proportions of caries were similar for older juveniles and adolescents in all three groups. In Group B, abscesses were recorded in a higher proportion of younger juveniles, than older juveniles or adolescents, and dental anomalies were also reported in a greater proportion of younger than older juveniles. However, these two conditions were observed in only a small number of non-adults in Group B and therefore any conclusions about their frequency rates must be made with caution.

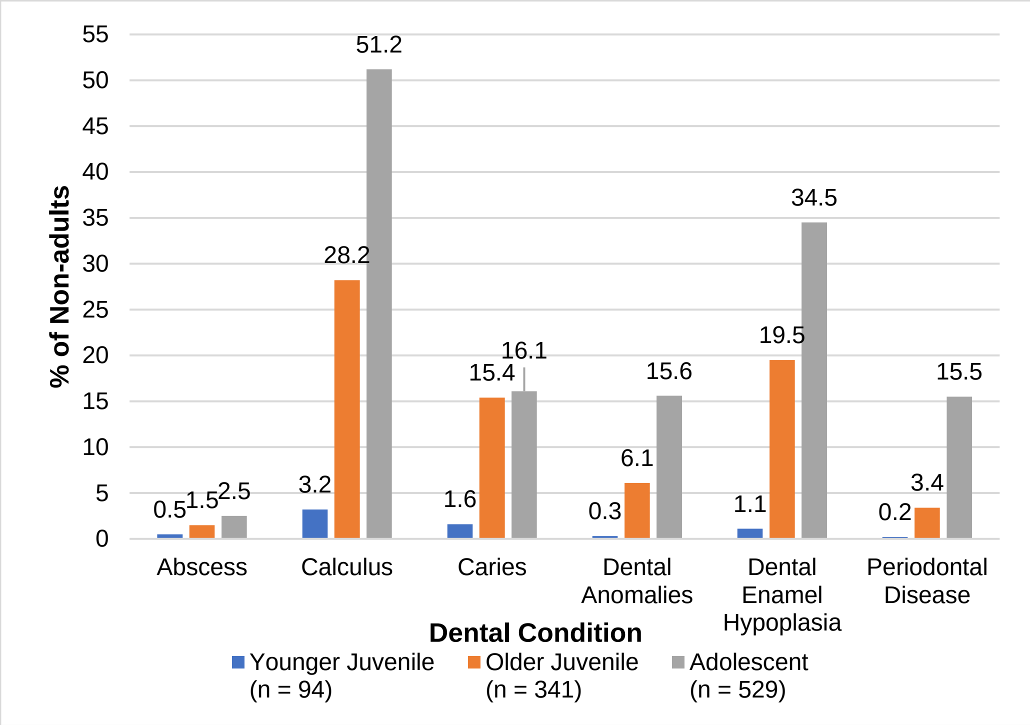


Figure 5.5.16 Percentage of non-adults recorded with dental conditions by age category in Group A (n = 964).

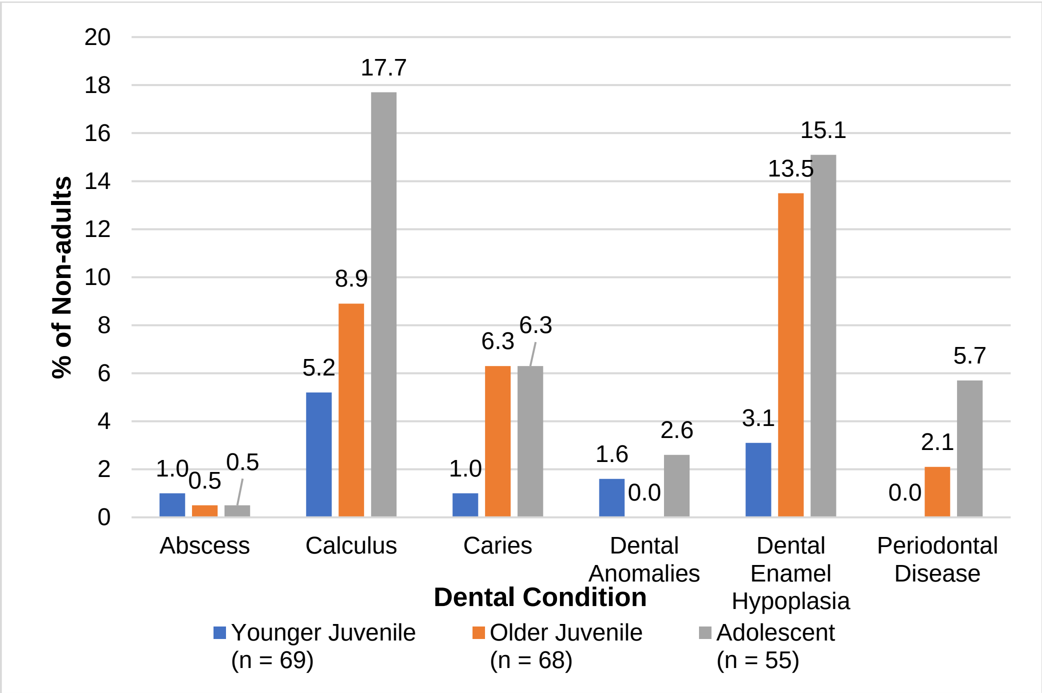


Figure 5.5.17 Percentage of non-adults recorded with dental conditions by age category in Group B (n = 192).

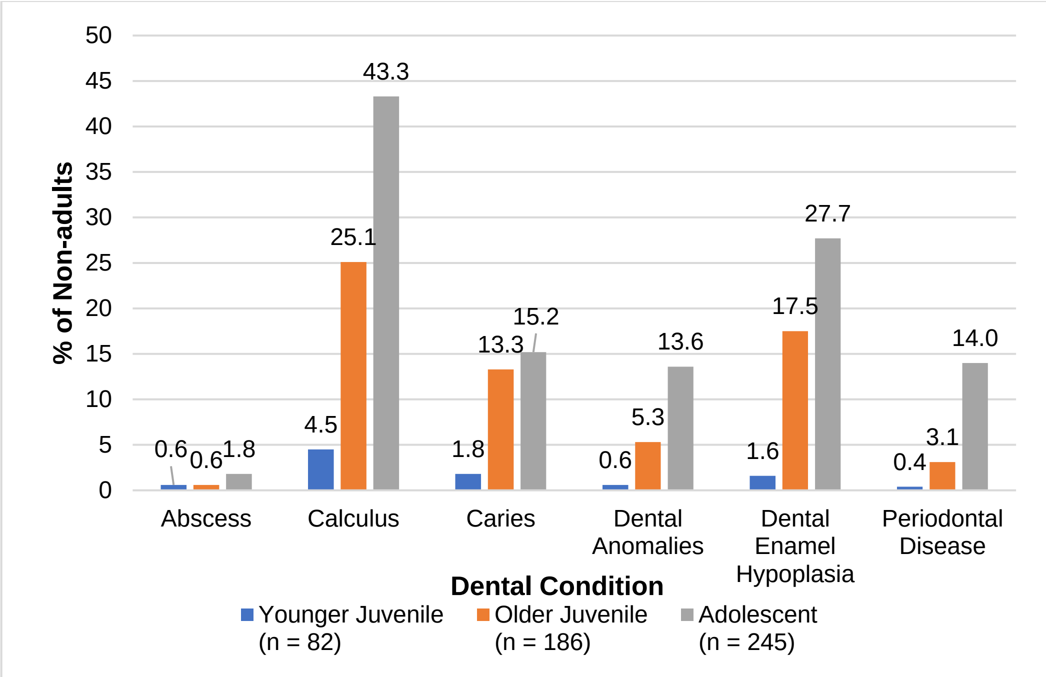


Figure 5.5.18 Percentage of non-adults recorded with dental conditions by age category in Group C (n = 513).

Where there was sufficient data, chi-square tests were utilised to assess if the difference between the presence of each individual dental condition by age category was statistically significant. The differences between the rates of each dental condition in younger juveniles and adolescents were statistically significant to the p = <0.01 value in all three groups (Table 5.5.18). An exception to this pattern was caries, for whom the difference between younger and older juveniles in Groups A and C, were also statistically significant.

Table 5.5.18 Results of chi-square analysis on dental conditions by age category in Groups A, B, and C.

Dental Condition	Group A (n = 964)	Group B (n = 192)	Group C (n = 513)
Calculus	χ^2 (2, n = 964) = 206.461, p = 0.000	χ^2 (2, n = 192) = 33.848, p = 0.000	χ^2 (2, n = 513) = 123.598, p = 0.000
Caries	χ^2 (2, n = 964) = 32.316, p = 0.000	χ^2 (2, n = 192) = 10.873, p = 0.004	χ^2 (2, n = 513) = 18.251, p = 0.000
Dental Anomalies	χ^2 (2, n = 964) = 36.226, p = 0.000	Not tested	χ^2 (2, n = 513) = 28.904, p = 0.000
Dental Enamel Hypoplasia (DEH)	χ^2 (2, n = 964) = 84.760, p = 0.000	χ^2 (2, n = 192) = 29.403, p = 0.000	χ^2 (2, n = 513) = 57.639, p = 0.000
Periodontal Disease	χ^2 (2, n = 964) = 65.292, p = 0.000	χ^2 (2, n = 192) = 17.542, p = 0.000	χ^2 (2, n = 513) = 46.971, p = 0.000

5.5.2 Disease and Hospital Location

Within the three hospital locations, 1,145 non-adults were from urban hospitals, 253 were reported from marginal sites, and 16 were identified at rural locations. When the data from St Mary Spital is removed in Group B, a lower number of non-adults were reported from urban (n = 112) than marginal hospitals (n = 253). A total of 735 (52.0%) non-adults in Group A exhibited a disease (excluding dental disease). In Group B, 163 (42.8%) individuals displayed evidence of disease, as did 408 (48.4%) non-adults in Group C.

The actual numbers of the total non-adult population under consideration exhibiting disease are highest from urban sites. However, the greatest proportion of non-adults displaying a particular disease is variable across the different hospital locations. For example, non-adults from urban sites have the highest number and rate of metabolic disease (n = 439, 38.3%), whereas the number of individuals with an infectious disease is greater from urban sites (n = 215, 18.8%), whilst the proportion of non-adults with an infectious disease is greatest from marginal hospitals (n = 66, 26.1%). This pattern varies in Groups B and C, as for example, a lower proportion of non-adults from urban than marginal hospitals in Group B exhibit metabolic conditions, as shown in Table 5.5.19.

Percentages have been calculated for the non-adult population within each type of hospital location. Therefore, the figures for marginal and rural hospitals are constant across Groups A, B and C. The differences in the numbers of non-adults with pathologies from urban hospitals between each of the three groups are stated in the tables in this section.

Table 5.5.19 Numbers and percentages of non-adults recorded with a pathology by hospital location in Groups A (n = 1,414), B (n = 381), and C (n = 843).

Disease Category	**Group A Urban (n = 1,145)**		**Group B Urban (n = 112)**		**Group C Urban (n = 574)**		**Marginal (n = 253)**		**Rural (n = 16)**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Congenital Disease	28	2.4	6	5.4	15	2.6	10	4.0	2	12.5
Metabolic Disease	439	38.3	14	12.5	183	31.9	71	28.1	3	18.8
Infectious Disease	215	18.8	25	22.3	113	19.7	66	26.1	2	12.5
Joint Disease	112	9.8	2	1.8	57	9.9	9	3.6	2	12.5
Miscellaneous Conditions	31	0.8	3	2.7	6	1.0	21	8.3	1	6.3
Dental Conditions	871	70.5	35	31.3	356	62.0	62	24.5	2	12.5

5.5.2.1 Congenital Conditions

In sum, 40 (2.8%) non-adults exhibited evidence of congenital conditions, the majority (n = 28, 70.0%) of whom were identified from urban hospitals. A total of 10 (25.0%) individuals were reported from marginal sites, and two (5.0%) were identified at rural hospitals. As shown in Table 5.5.20, congenital syphilis, developmental dysplasia of the hip, and scoliosis were only recorded at urban hospitals, whilst the only observation of Klippel-Feil syndrome was reported from a marginal hospital.

Table 5.5.20 Number and percentages of congenital conditions recorded by hospital location.

Congenital Disease	**Group A Urban (n = 1,145)**		**Group B Urban (n = 112)**		**Group C Urban (n = 574)**		**Marginal (n = 253)**		**Rural (n = 16)**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Congenital Fusion	5	0.4	2	1.8	4	0.7	4	1.6	0	0.0
Congenital Syphilis	3	0.3	1	0.9	3	0.5	0	0.0	0	0.0
Cranial Anomalies	7	0.6	1	0.9	1	0.2	0	0.0	2	12.5
Developmental Dysplasia of the Hip	2	0.2	0	0.0	1	0.2	0	0.0	0	0.0
Klippel-Feil Syndrome	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0
Spina Bifida Occulta	2	0.2	2	1.8	2	0.3	3	1.2	0	0.0
Other Spinal Disorders	5	0.4	1	0.9	4	0.7	2	0.8	1	6.3
Scoliosis	3	0.3	1	0.9	2	0.3	0	0.0	0	0.0
Spondylolysis	5	0.4	0	0.0	1	0.2	1	0.4	0	0.0

5.5.2.2 Metabolic Disease

A total of 513 (36.3%) non-adults showed evidence of a metabolic condition. The greatest proportion of these individuals, 439 (85.6%), were from urban hospitals, whilst 71 (13.8%) were identified at marginal sites, and three (0.6%) were reported from rural locations. A single non-adult from an urban hospital was observed to have a kidney stone. Porotic hyperostosis (n = 98) was only recorded by the osteologist at St Mary Spital, London, an urban hospital (Table 5.5.21).

Table 5.5.21 Number and percentages of congenital conditions recorded by hospital location.

Metabolic Disease	**Group A Urban (n = 1,145)**		**Group B Urban (n = 112)**		**Group C Urban (n = 574)**		**Marginal (n = 253)**		**Rural (n = 16)**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Cribra Orbitalia	397	34.7	14	12.5	158	27.5	71	22.5	3	18.8
Kidney Stone	1	0.1	0	0.0	1	0.2	0	0.0	0	0.0
Porotic Hyperostosis	98	8.6	0	0.0	40	7.0	0	0.0	0	0.0
Vitamin D deficiency (rickets)	5	0.4	0	0.0	3	0.5	11	4.3	0	0.0
Vitamin C deficiency (scurvy)	6	0.5	0	0.0	2	0.3	9	3.6	0	0.0

Of the 457 (32.3%) non-adults with cribra orbitalia, 397 (86.9%) were recorded from urban hospitals, 57 (12.5%) from marginal sites, and three (0.7%) from rural hospitals. In Groups A and C, the highest proportions of non-adults exhibiting cribra orbitalia were from urban hospitals, although in Group B they were from marginal sites (Figure 5.5.19). Chi-square results demonstrate that this difference in occurrence of cribra orbitalia by location was statistically significant in Group A (χ^2 (2, n = 1,414) = 15.330, p = 0.000) (p = <0.01) and Group B (χ^2 (2, n = 381) = 4.995, p = 0.082) (p = <0.05). Yet, the difference was insignificant in Group C (χ^2 (2, n = 843) = 2.717, p = 0.257) at the p = <0.05 level.

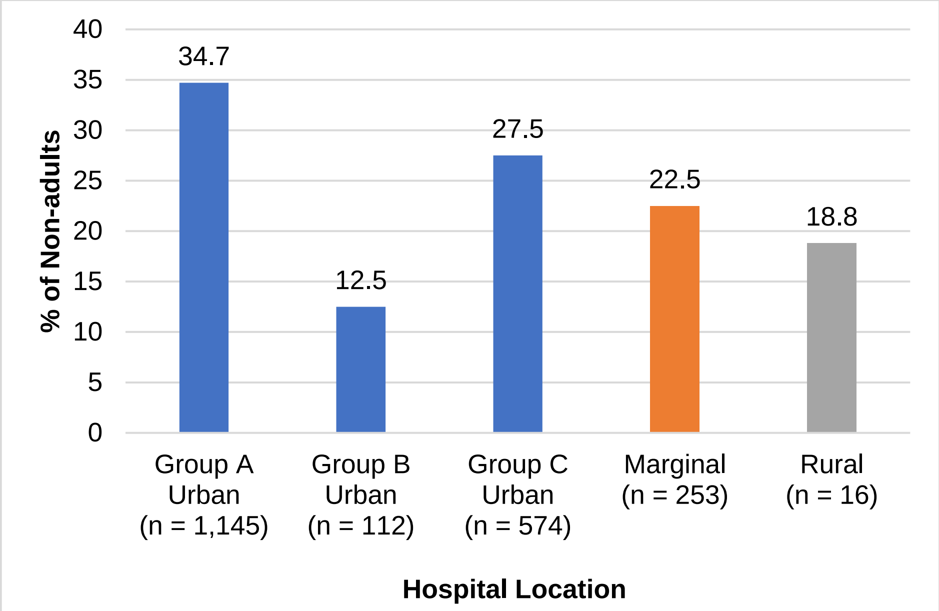


Figure 5.5.19 Percentage of non-adults recorded with cribra orbitalia by hospital location.

Vitamin D deficiency (rickets) was reported for a total of 16 non-adults and vitamin C deficiency (scurvy) was reported in 15 non-adults. As shown in Figure 5.5.20, both pathologies were reported in a notably higher proportion of non-adults from marginal hospitals than urban locations. In Group B, the conditions are recorded solely at marginal hospitals, demonstrating that the only urban hospital where rickets or scurvy were identified was St Mary Spital, London. Neither scurvy nor rickets were observed on the 16 non-adults from rural hospital locations.

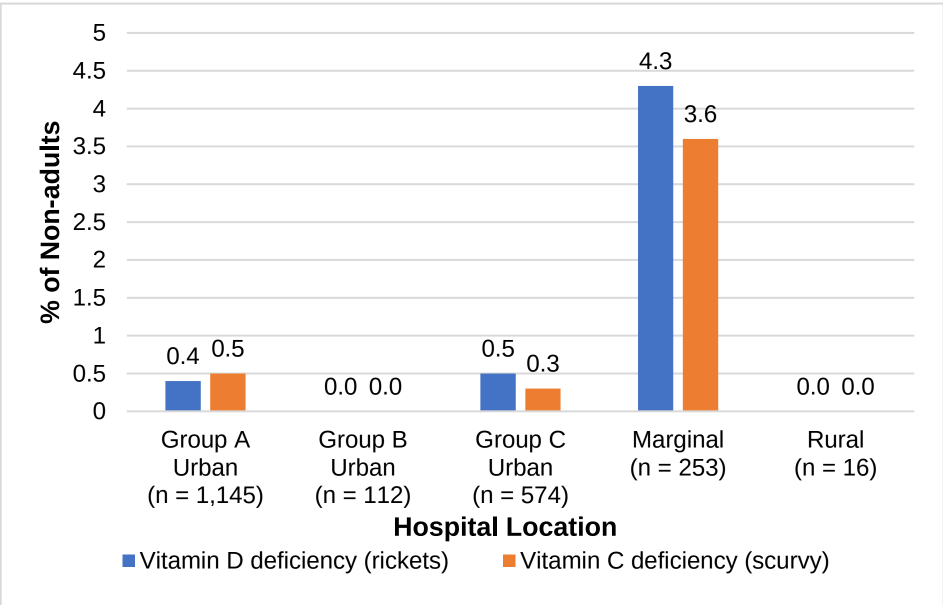


Figure 5.5.20 Percentage of non-adults recorded with Vitamin D deficiency (rickets) or Vitamin C deficiency (scurvy) by hospital location.

5.5.2.3 Infectious Disease

Within Group A, 283 (20.0%) non-adults were reported as showing evidence of an infectious disease. These 283 individuals comprised 215 (18.8%) of the non-adults recorded from urban hospitals, 66 (26.1%) of the non-adult population from marginal sites, and two (12.5%) of the non-adults from rural locations (Tables 5.5.22 to 5.5.24). The difference in the proportions of non-adults reported with an infectious disease in urban and marginal hospitals was statistically significant in Group A (χ^2 (2, n = 1,414) = 7.348, p = 0.025) at the p = <0.05 value. However, the differences in infectious disease by hospital location was statistically insignificant in Group B (χ^2 (2, n = 381) = 1.307, p = 0.520) and Group C (χ^2 (2, n = 843) = 4.347, p = 0.114).

Table 5.5.22 Numbers and percentages of infectious disease recorded by hospital location.

Infectious Disease	Group A Urban (n = 1,145)		Group B Urban (n = 112)		Group C Urban (n = 574)		Marginal (n = 253)		Rural (n = 16)	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Bowel Infection	2	0.2	0	0.0	0	0.0	0	0.0	0	0.0
Fungal Infection	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
Leprosy	0	0.0	0	0.0	0	0.0	23	9.1	1	6.3
Rhinitis	0	0.0	0	0.0	0	0.0	2	0.8	0	0.0
Sinusitis	12	1.0	9	8.0	10	1.7	5	2.0	1	6.3
Treponemal Disease	3	0.3	0	0.0	3	0.5	1	0.4	0	0.0

As shown in Table 5.5.22, leprosy was not observed on any non-adults from urban hospitals. Of the 24 non-adults reported with skeletal evidence of leprosy, 23 (95.8%) were reported from marginal locations, and a single individual (4.2%) was from a rural hospital. Group B data were tested using chi-square and a statistically significant (p = <0.01) difference was found between the presence of leprosy in urban and marginal hospitals (χ^2 (2, n = 381) = 10.870, p = 0.004). All of the individuals with leprosy were recorded from four hospital sites, each of which functioned as leprosaria: 18 (75.0%) were reported from St Mary Magdalene, Winchester, two (8.3%) from St Margaret, Huntingdon, three (12.5%) were identified at St Leonard's, Peterborough, and a single (4.2%) individual was recorded from St Mary Magdalen, Bidlington.

Sinusitis was reported in too few individuals to permit statistical analysis. However, it is notable that in Groups A and C, the proportions of non-adults exhibiting sinusitis are similar for urban and marginal sites, with a higher proportion recorded from urban hospitals in Group B. Similarly, the percentages of non-adults in Group A reported with treponemal disease are similar in urban and marginal sites. The urban cases were all reported from St Mary Spital, London, and consequently, in Group B, there were no non-adults from urban hospitals with treponemal disease.

Table 5.5.23 Numbers and percentages of respiratory infectious diseases recorded by hospital location.

Respiratory Infectious Disease	Group A Urban (n = 1,145)		Group B Urban (n = 112)		Group C Urban (n = 574)		Marginal (n = 253)		Rural (n = 16)	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Rib Lesions	0	0.0	0	0.0	0	0.0	4	0.0	0	0.0
Tuberculosis	22	1.9	2	1.8	11	1.9	11	4.3	0	0.0

Rib lesions, which are indicative of respiratory infection were only observed on non-adults from marginal sites (Table 5.5.23). Yet, evidence of tuberculosis (TB) was identified on non-adults from both urban and marginal hospitals, although not from rural hospitals. The proportions of non-adults from urban hospitals reported with TB are consistent across Groups A, B, and C. Overall, a higher rate of TB was identified on non-adults from marginal sites. The Group A (χ^2 (2, n = 1,414) = 5.739, p = 0.057) and Group C (χ^2 (2, n = 843) = 4.522, p = 0.104) data were tested using chi-square to determine if this difference was significant. The results were statistically insignificant (p = <0.05), although the Group A result is only marginally so.

Table 5.5.24 Numbers and percentages of non-specific infectious diseases recorded by hospital location.

Non-specific Infectious Disease	Group A Urban (n = 1,145)		Group B Urban (n = 112)		Group C Urban (n = 574)		Marginal (n = 253)		Rural (n = 16)	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Endocranial Lesions	36	3.1	2	1.8	16	2.8	5	2.0	0	0.0
Mastoiditis	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
Osteitis	5	0.4	0	0.0	3	0.5	2	0.8	0	0.0
Osteolytic Lesions	0	0.0	0	0.0	0	0.0	2	0.8	0	0.0
Osteomyelitis	5	0.4	0	0.0	2	0.3	2	0.8	0	0.0
Otitis Media	2	0.2	1	0.9	1	0.2	0	0.0	0	0.0
Otosclerosis	0	0.0	0	0.0	0	0.0	2	0.8	0	0.0
Subperiosteal New Bone Formation	149	13.0	15	13.4	79	13.8	46	18.2	1	6.3

Endocranial lesions were identified in 41 (2.9%) of the total non-adult population: 36 (3.1%) from within urban hospitals and five (2.0%) from marginal hospital locations. No observations of endocranial lesions were reported from rural hospitals. In Groups A and C, the rate of endocranial lesions reported are greater from urban than marginal hospitals, although in Group B, the proportions of endocranial lesions are slightly lower in non-adults from urban hospitals (Table 5.5.24).

As illustrated in Figure 5.5.21, the rates of non-adults observed with subperiosteal new bone formation is relatively consistent in urban hospitals in Groups A, B, and C. By comparison, a greater proportion of non-adults from hospitals in marginal locations were reported with subperiosteal new bone formation, whilst the figure was lower in rural hospitals. This difference was statistically insignificant ($p = <0.05$) for all three groups: Group A (χ^2 (2, n = 1,414) = 5.422, p = 0.066), Group B (χ^2 (2, n = 381) = 2.538, p = 0.281), and Group C (χ^2 (2, n = 843) = 3.667, p = 0.160).

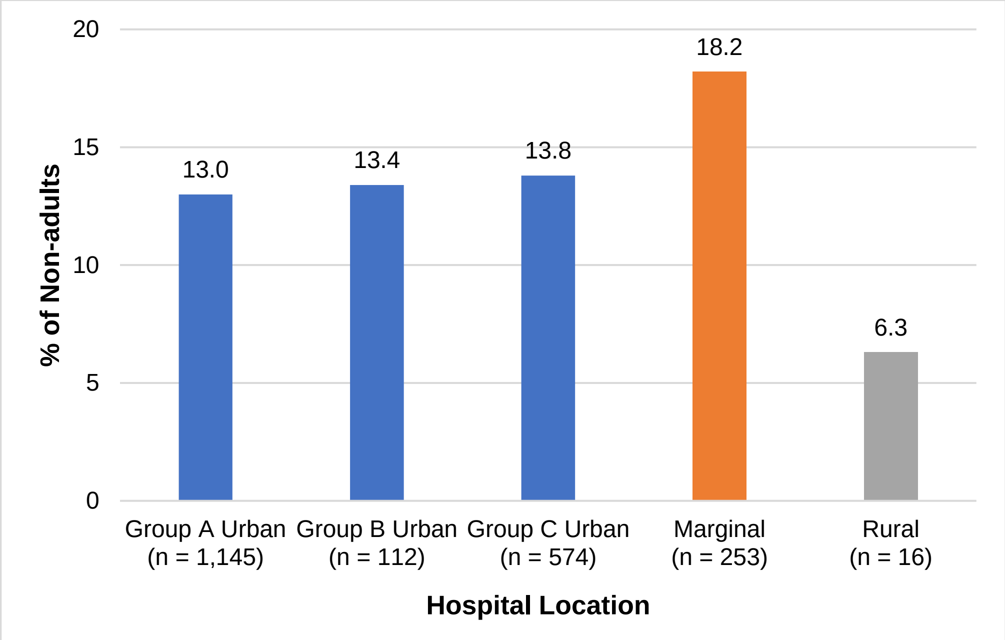


Figure 5.5.21 Percentage of non-adults recorded with subperiosteal new bone formation by hospital location.

Table 5.5.25 shows that the most frequently occurring skeletal location for subperiosteal new bone formation were the lower long bones at both urban and marginal hospitals. At urban locations this was followed by the axial bones. Although in marginal hospitals subperiosteal new bone formation was more often identified on the skull than the axial bones. Only a single non-adult from a rural hospital was recorded with subperiosteal new bone formation and this was observed on the lower long bones.

Table 5.5.25 Numbers and percentages of the skeletal location of subperiosteal new bone formation recorded on non-adults by hospital location.

Location of subperiosteal new bone formation	**Group A Urban (n = 1,145)**		**Group B Urban (n = 112)**		**Group C Urban (n = 574)**		**Marginal (n = 253)**		**Rural (n = 16)**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Skull	15	1.3	0	0.0	4	0.7	11	4.3	0	0.0
Axial (spine and ribs)	51	4.5	4	3.6	28	4.9	4	1.6	0	0.0
Upper Long Bones	15	1.3	1	0.9	11	1.9	5	2.0	0	0.0
Lower Long Bones	81	7.1	7	6.3	42	7.3	29	11.5	1	6.3

Woven bone was reported on nearly 10% of non-adults from urban hospitals in Groups A and C, and this fell to 6.3% of non-adults in Group B. The proportion of non-adults recorded with woven bone from marginal hospitals is between these figures (7.5%), indicating a relatively similar percentage of non-adults died at urban and marginal hospitals with an active infection. The proportion of non-adults observed with lamellar bone is higher in all three groups at urban sites (notably in Group B) than from marginal hospitals, suggesting a higher proportion of non-adults with a healed infection died at urban hospitals. The data for non-adults recorded with both woven and lamellar bone follows a similar pattern (Table 5.5.26).

Table 5.5.26 Numbers and percentages of the appearance of subperiosteal new bone formation recorded on non-adults by hospital location.

Appearance of subperiosteal new bone formation	**Group A Urban (n = 1,145)**		**Group B Urban (n = 112)**		**Group C Urban (n = 574)**		**Marginal (n = 253)**		**Rural (n = 16)**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Woven	109	9.5	7	6.3	56	9.8	19	7.5	0	0.0
Lamellar	42	3.7	8	7.1	22	3.8	4	1.6	0	0.0
Woven and Lamellar	13	1.1	5	4.5	9	1.6	1	0.4	0	0.0

5.5.2.4 Joint Disease

Joint disease was recorded in 123 (8.7%) non-adults. The majority of these individuals (n = 112, 91.1%) were identified at urban hospitals, nine (7.3%) were reported from marginal locations, and two (1.6%) individuals were from rural hospitals. As shown in Table 5.5.27, most of the non-adults observed with a joint disease were from St Mary Spital, London, as only two non-adults from other urban hospitals were recorded exhibiting joint disease.

Table 5.5.27 Numbers and percentages of joint disease recorded by hospital location.

	Group A Urban (n = 1,145)		Group B Urban (n = 112)		Group C Urban (n = 574)		Marginal (n = 253)		Rural (n = 16)	
Joint Disease	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Ankylosis	4	0.3	1	0.9	2	0.3	2	0.8	1	6.3
Intervertebral Osteochondrosis	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0
Intervertebral Disc Disease	3	0.3	0	0.0	2	0.3	0	0.0	0	0.0
Osteoarthritis	3	0.3	0	0.0	2	0.3	1	0.4	0	0.0
Osteophytes	1	0.1	0	0.0	1	0.2	0	0.0	0	0.0
Schmorl's nodes	103	9.0	1	0.9	51	8.9	6	2.4	1	6.3
Septic Arthritis	1	0.1	0	0.0	0	0.0	2	0.8	0	0.0
Spinal Degenerative Changes	1	0.1	1	0.9	1	0.2	0	0.0	0	0.0

With the exception of Schmorl's nodes, joint diseases were each recorded in relatively low numbers of non-adults (fewer than four) in urban, marginal, and rural hospital locations. Schmorl's nodes were reported in 110 (7.8%) non-adults, accounting for 89.4% of the 124 individuals with a joint disease. Figure 5.5.22 illustrates the higher proportion of non-adults observed with Schmorl's nodes from urban hospitals in Groups A and C in contrast to the lower proportion recorded from marginal hospitals. This difference was statistically significant ($p = <0.01$) in both Group A (χ^2 (2, n = 1,414) = 12.726, $p = 0.002$) and Group C (χ^2 (2, n = 843) = 11.638, $p = 0.003$). The data in Group B were insufficient to permit chi-square testing, however it can be seen that the percentage of non-adults with the condition from urban hospitals was lower compared to those from marginal or rural hospitals.

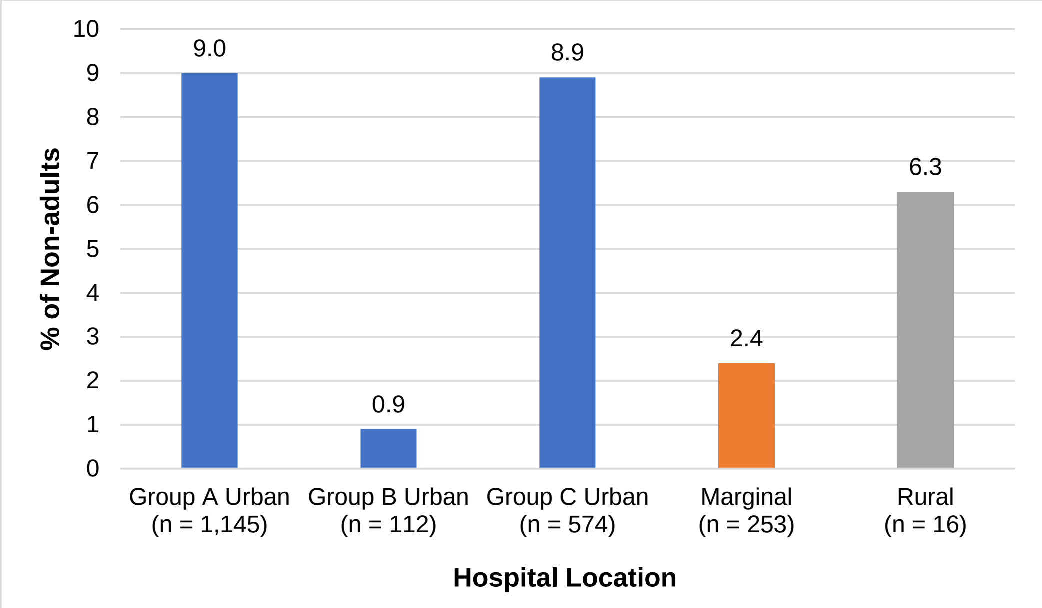


Figure 5.5.22 Percentage of non-adults recorded with Schmorl's nodes by hospital location.

5.5.2.5 Miscellaneous Conditions

Conditions categorised as miscellaneous, were recorded on a total of 31 (2.2%) non-adults. The majority of whom (n = 22) where observed to have a discrepancy in their age due to differences in the estimated age obtained by osteologists using dental and long bone length methods of determining age. As shown in Table 5.5.28, most other conditions were observed only once within the hospital non-adult population, with osteochondroma reported for three individuals.

Table 5.5.28 Numbers and percentages of miscellaneous conditions recorded by hospital location.

Miscellaneous Condition	Group A Urban (n = 1,145)		Group B Urban (n = 112)		Group C Urban (n = 574)		Marginal (n = 253)		Rural (n = 16)	
	No.	%	No.	%	No.	%	No.	%	No.	%
Age Discrepancy	1	0.1	1	0.9	1	0.2	20	7.9	1	6.25
Bone Cysts	1	0.1	0	0.0	1	0.2	0	0.0	0	0.0
Chondroma	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0
Neoplastic Disorder	1	0.1	1	0.9	1	0.2	0	0.0	0	0.0
Osteochondroma	3	0.3	0	0.0	2	0.3	0	0.0	0	0.0
Osteoid Osteoma	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0
Torticolis	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0

A total of 20 non-adults with an observed age discrepancy were from marginal hospitals, with a single non-adult reported from an urban and a rural hospital. Only the data in Group C were sufficient in numbers and spread to conduct a chi-square test to assess the significance of this difference, and the result was statistically significant ($p = <0.01$) (χ^2 (2, n = 843) = 42.144, p = 0.000). As stated in Section 5.4.1.5, the majority of non-adults reported to have a discrepancy in their age estimates came from a single marginal site, St Mary Magdalene, Winchester (n = 17, 77.3%). This hospital was a leprosarium and therefore it is possible that the cause of the age discrepancies in such a high proportion of non-adults from this site is associated with the health conditions of the hospital inmates, the particular environmental conditions of the hospital, or potentially the research focus of the osteologist.

5.5.2.6 Dental Conditions

Of the 1,414 non-adults from medieval hospital sites, 964 (68.2%) retained teeth which were osteologically examined; 794 (82.4%) from urban hospitals, 164 (17.0%) from marginal locations, and six (0.6%) from rural sites. Due to the low number of individuals from rural sites, the data violated chi-square test assumptions and therefore the occurrence of dental disease across the three types of hospital location, could not be statistically tested. However, as shown in Table 5.5.28 and Figure 5.5.23, the number of non-adults with each dental disease is proportionately higher in each instance in those from urban hospital, than in marginal locations. Caries, dental enamel hypoplasia (DEH), and calculus were each reported in only one individual (16.7%) from rural hospitals. Table 5.5.29 further shows that a greater proportion of non-adults from St Mary Spital, were observed with caries, dental anomalies, and periodontal disease, than from other urban hospitals. Comparatively similar proportions of non-adults were reported from urban hospitals in Groups A and B with abscesses, calculus, and DEH.

Table 5.5.29 Numbers and percentages of miscellaneous conditions recorded by hospital location.

Dental Condition	Group A Urban (n = 811)		Group B Urban (n = 39)		Group C Urban (n = 360)		Marginal (n = 147)		Rural (n = 6)	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Abscess	41	5.1	2	5.1	13	3.6	2	1.4	0	0
Caries	759	93.6	23	59.0	336	93.3	37	25.2	1	16.7
Calculus	305	37.6	13	33.3	142	39.4	12	8.2	1	16.7
Dental Anomalies	208	25.6	4	10.3	96	26.7	4	2.7	0	0.0
Dental Enamel Hypoplasia (DEH)	494	60.9	23	59.0	202	56.1	37	25.2	1	16.7
Periodontal Disease	171	21.1	2	5.1	77	21.4	13	8.8	0	0.0

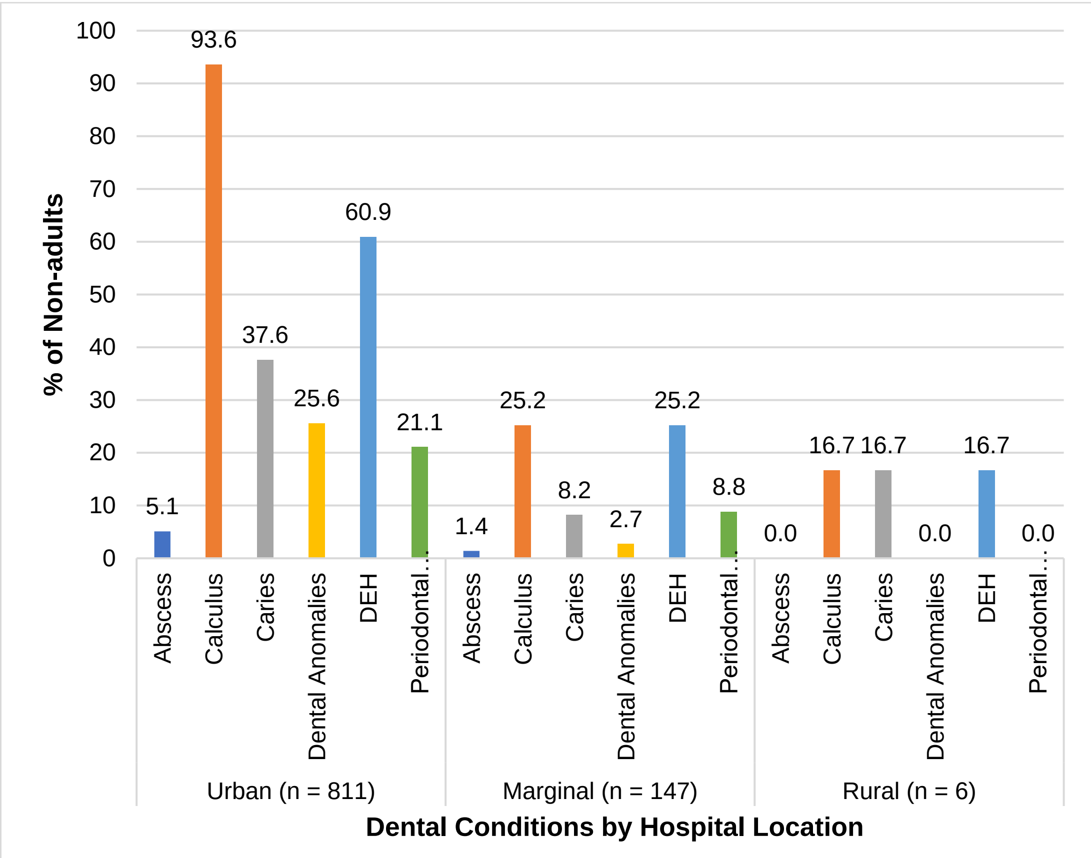


Figure 5.5.23 Percentage of non-adults recorded with dental conditions by hospital location in Group A (n = 964).

5.5.3 Summary

The majority of diseases recorded in osteology reports were found to occur in lower numbers of younger juveniles, and in higher numbers of adolescents. This finding is to be expected as the possibility of acquiring a disease increases with age. The exceptions to this pattern are rickets and age discrepancies, which were identified in more younger juveniles. Similarly, caries were reported in higher numbers of older juveniles and fewer adolescents. In relation to hospital locations, overall, metabolic and joint diseases, and dental conditions were more prevalent at urban hospitals. Infectious diseases were reported in higher proportions of non-adults from marginal sites. However, when the data from St Mary Spital were removed from the dataset, in Group B, the proportion of non-adults reported with a pathology were greater from marginal than urban hospitals, with the exception of dental disease.

5.6 General Stress Indicators

The three general stress indicators analysed in this section are cribra orbitalia, subperiosteal new bone formation, and dental enamel hypoplasia (DEH). These pathologies were selected as they have multiple aetiologies which are associated with general episodes of infection, nutritional deficiency, and environmental strains, within an individual's life (Dawson, 2014; Mays, 2010a). The data related to the presence of these individual stress indicators by age and hospital location are stated above (Section 5.5). In this section they are explored to test the null hypotheses and associated questions 6 – 10 (Appendix 3) in relation to the presence of multiple stress indicators by age categories, relationships with other pathologies, and by whether a non-adult observed with one indicator is more likely to exhibit a second stress indicator.

As previously stated (Section 4.3.7), the absence of a pathology can be due to skeletal completeness and preservation, and variations in osteological methods used to observe and record pathologies. Thus, an individual may have experienced illnesses or environmental stress in life which are not possible to record archaeologically.

5.6.1 Individual Stress Indicators and Disease

Many of the pathologies recorded in osteological reports were observed in too few numbers of non-adults to draw conclusions about their presence in relation to general stress indicators. Additionally, due to the small numbers under consideration, the non-adult hospital population who were osteologically examined beyond demographic data (n = 1,414) is discussed in its entirety in this section. Of this population 457 (32.3%) exhibited cribra orbitalia, 196 (13.9%) were reported with subperiosteal new bone formation, and 532 (55.2%) had dental enamel hypoplasia (DEH).

5.6.1.1 Stress Indicators and Metabolic Disease

Table 5.6.1 shows that of the non-adults recorded with Vitamin D deficiency rickets, only a small percentage also exhibited any of the three general stress indicators. Of those reported with Vitamin C deficiency scurvy, a condition associated with a diet lacking fresh fruit and vegetables, nearly one-half of non-adults also exhibited cribra orbitalia. Although, as discussed by Manchester and Roberts (2010) orbital lesions may be the result of scurvy. One-third of non-adults exhibiting Vitamin C deficiency scurvy were also reported with DEH..

Table 5.6.1 Number and percentages of non-adults recorded with metabolic diseases by the presence of individual general stress indicators.

Metabolic Disease	**Cribra Orbitalia**		**Subperiosteal new bone formation**		**Dental Enamel Hypoplasia (DEH)**	
	Number	%	Number	%	Number	%
Vitamin D deficiency Rickets (n = 16)	2	12.5	1	6.3	1	6.3
Vitamin C deficiency Scurvy (n = 15)	7	46.7	1	6.7	5	33.3

5.6.1.2 Stress Indicators and Infectious Disease

The proportions of non-adults with an infectious disease, exhibited higher rates of cribra orbitalia than were found within the non-adult hospital population as a whole (Table 5.6.2). This is particularly notable for non-adults who were reported with endocranial lesions, 63.4% of whom were also recorded with cribra orbitalia. Subperiosteal new bone formation was reported in a higher proportion of non-adults with leprosy, sinusitis, and tuberculosis (TB). However, subperiosteal new bone formation on particular bones is used as a diagnostic indicator of leprosy and TB, and therefore it may be expected that non-adults recorded with these pathologies were observed with subperiosteal new bone formation. DEH was reported in a lower percentage of non-adults with leprosy and a greater proportion of those with sinusitis than the hospital population average, yet in a similar proportion of non-adults with TB or endocranial lesions.

Table 5.6.2 Number and percentages of non-adults recorded with infectious diseases by the presence of individual general stress indicators.

Infectious Disease	**Cribra Orbitalia**		**Subperiosteal new bone formation**		**Dental Enamel Hypoplasia**	
	Number	%	Number	%	Number	%
Leprosy (n = 24)	11	45.8	17	70.8	7	29.2
Sinusitis (n = 18)	9	50.0	7	38.9	13	72.2
Tuberculosis (n = 33)	16	48.5	13	39.4	18	54.5
Endocranial Lesions (n = 41)	26	63.4	4	9.8	19	46.3

5.6.1.2 Stress Indicators and Joint Disease

Of the 110 non-adults with Schmorl's nodes, a slightly higher proportion were recorded with cribra orbitalia than the non-adult hospital population as a whole. The percentage who also exhibited subperiosteal new bone formation, compared with non-adults who were not reported with a joint disease, was statistically significant (χ^2 (1, n = 1,414) = 16.243, p = 0.000) at the p = <0.01 level. Whilst non-adults with Schmorl's nodes who also displayed DEH was proportionally similar to the whole non-adult population, the difference was also statistically significant (χ^2 (1, n = 1,414) = 18.809, p = 0.000) (Table 5.6.3).

Table 5.6.3 Number and percentages of non-adults recorded with Schmorl's nodes by the presence of individual general stress indicators.

Joint Disease	**Cribra Orbitalia**		**Subperiosteal new bone formation**		**Dental Enamel Hypoplasia**	
	Number	%	Number	%	Number	%
Schmorl's nodes (n = 110)	42	38.2	27	24.5	61	55.5

5.6.1.3 Stress Indicators and Dentition

A total of 964 (68.2%) non-adults retained dentition or an associated mandible or maxilla, which were reported on in osteological reports. Of these 964 individuals, 429 (44.5%) exhibited cribra orbitalia, 140 (14.5%) showed evidence of subperiosteal new bone formation, and 532 (55.2%) displayed dental enamel hypoplasia (DEH).

As illustrated in Table 5.6.4, a higher proportion of non-adults who exhibited a dental condition were reported with cribra orbitalia, compared to non-adults who were not reported with a dental condition. Chi-square tests show this difference was statistically significant (p = <0.05) in respect to the presence of caries (χ^2 (1, n = 964) = 3.986, p = 0.046), periodontal disease (χ^2 (1, n = 964) = 9.938, p = 0.002), and calculus (χ^2 (1, n = 964) = 9.841, p = 0.002). A relatively similar proportion of non-adults with the different dental conditions exhibited subperiosteal new bone formation compared to the average prevalence rate (14.5%). However, of the non-adults reported with subperiosteal new bone formation, a statistically significant number were more likely than those who did not exhibit subperiosteal new bone formation to display calculus (χ^2 (1, n = 964) = 3.974, p = 0.046) and periodontal disease (χ^2 (1, n = 964) = 11.031, p = 0.001) (p = <0.05). Yet, the relationship between the presence of subperiosteal new bone formation and caries was statistically insignificant (p = <0.05) (χ^2 (1, n = 964) = 0.300, p = 0.584).

The rates of DEH in non-adults reported with a dental condition are all greater than the average for the whole population. This difference between the prevalence of DEH in non-adults with or without a dental condition was statistically significant (p = <0.05) in relation to the presence of caries (χ^2 (1, n = 964) = 7.220, p = 0.007), calculus (p = <0.01) (χ^2 (1, n = 964) = 47.238, p = 0.000), and marginally significant for dental anomalies (χ^2 (1, n = 964) = 4.135, p = 0.042).

Table 5.6.4 Number and percentages of non-adults recorded with dental conditions by the presence of individual general stress indicators.

Dental Condition	Cribra Orbitalia		Subperiosteal new bone formation		Dental Enamel Hypoplasia	
	Number	%	Number	%	Number	%
Abscess (n = 43)	25	58.1	5	11.6	26	60.5
Calculus (n = 797)	373	46.8	124	15.6	480	60.2
Caries (n = 318)	156	49.1	49	15.4	195	61.3
Dental Anomalies (n = 212)	104	49.1	34	16.0	130	61.3
Periodontal Disease (n = 184)	101	54.9	41	22.3	108	58.7

5.6.2 Multiple Stress Indicators

In the following sections, non-adults are discussed who had a combination of two or all three of the general stress indicators (cribra orbitalia, subperiosteal new bone formation, and DEH). As seen in Table 5.6.5, nearly one-fifth of all non-adults recorded from medieval hospital sites were observed with two general stress indicators. This figure falls to less than 10.0% of non-adults when the data from St Mary Spital, London is removed from the dataset. The percentage of non-adults recorded in Group C is between Groups A and B, at 14.6%. The type 'D' burials from St Mary Spital (n = 571), who were possibly residents of London rather than hospital inhabitants (Connell *et al*. 2012), accounted for 54.4% (n = 147) of the total number of non-adults from all hospital sites found to have two stress indicators, and 45.7% (n = 21) of non-adults who exhibited all three general stress indicators.

Table 5.6.5 Number and percentages of non-adults recorded with two or three general stress indicators in Groups A, B, and C.

Number of Stress Indicators Present	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
	Number	%	Number	%	Number	%
Two	270	19.1	35	9.2	123	14.6
Three	46	3.3	8	2.1	25	3.0

5.6.2.1 Multiple Stress Indicators and Age

When the presence of multiple stress indicators was divided by age category, it was apparent that the presence of both two and three stress indicators increases with age in all three groups. Although, the greatest difference in the presence of multiple stress indicators by age category was seen in Group A (Table 5.6.6). In all three groups, the difference between the occurrence of two stress indicators in younger juveniles and adolescents was statistically significant: in Group A (χ^2 (2, n = 1,414) = 62.442, p = 0.000), and Group C (χ^2 (2, n = 843) = 42.029, p = 0.000), at the p = <0.01 level, and in Group B (χ^2 (2, n = 381) = 12.950, p = 0.002) at the p = <0.05 level. No younger juveniles were recorded exhibiting all three stress indicators. A statistical significance (p = <0.01) was found in Groups A and C when the difference in the presence of three stress indicators by age category was tested using chi-square: Group A (χ^2 (2, n = 1,414) = 18.757, p = 0.000) and Group C (χ^2 (2, n = 843) = 20.010, p = 0.000). The data in Group B was too small to permit statistical analysis, however a similar trend can be seen in Figure 5.6.1.

Table 5.6.6 Number and percentages of non-adults recorded with two or three general stress indicators by age category in Groups A, B, and C.

	Group A (n = 1,414)				**Group B (n = 381)**				**Group C (n = 843)**			
	Two General Stress Indicators		Three General Stress Indicators		Two General Stress Indicators		Three General Stress Indicators		Two General Stress Indicators		Three General Stress Indicators	
Age Category	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Younger Juvenile	10	0.7	0	0.0	6	1.6	0	0.0	8	0.9	0	0.0
Older Juvenile	99	7.0	12	0.8	12	3.1	1	0.3	42	5.0	5	0.6
Adolescent	161	11.4	34	2.4	17	4.5	7	1.8	73	8.7	20	2.4

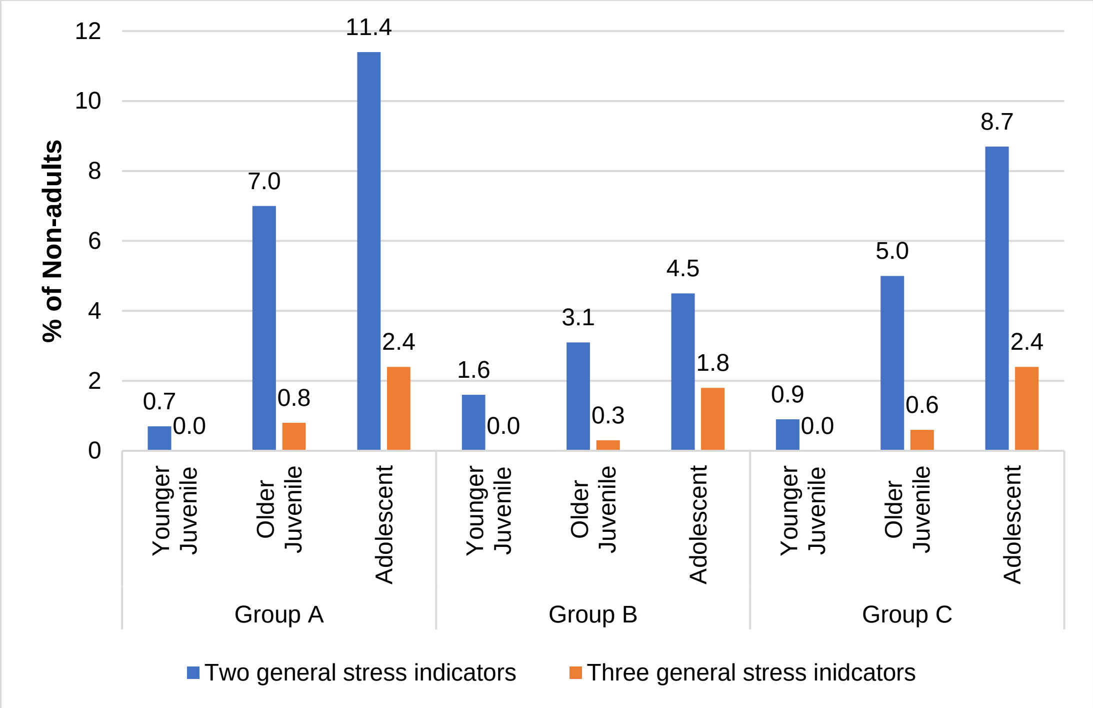


Figure 5.6.1 Percentages of non-adults recorded with two or three general stress indicators by age category in Groups A, B, and C.

5.6.2.2 Multiple Stress Indicators and Hospital Location

Most non-adults reported with two or three general stress indicators were from St Mary Spital, London, as a higher proportion of non-adults from urban hospitals in Groups A and C, were recorded with multiple indicators than those from urban hospitals in Group B. Consequently, the proportion of non-adults with multiple stress indicators from marginal hospitals was lower than that observed in urban hospitals in Groups A and C, but higher than in Group B. This difference for two general stress indicators by hospital location was statistically significant (p = <0.01) in Group A (χ^2 (2, n = 1,414) = 16.413, p = 0.000). The proportions of non-adults exhibiting two general stress indicators from rural hospitals was comparable to those from urban hospitals in Group B. No non-adults from rural hospitals exhibited all three stress indicators (Table 5.6.7).

Table 5.6.7 Number and percentages of non-adults recorded with two or three general stress indicators by hospital location in Groups A, B, and C.

Number of Stress Indicators Present	Group A Urban (n = 1,145)		Group B Urban (n = 112)		Group C Urban (n = 574)		Marginal (n = 253)		Rural (n = 16)	
	No.	%	No.	%	No.	%	No.	%	No.	%
Two	242	21.1	7	6.25	96	16.7	27	10.7	1	6.3
Three	39	3.4	1	0.9	18	3.1	7	2.8	0	0.0

5.6.2.3 Multiple Stress Indicators and Disease

As stated in Section 5.6.1, due to the small numbers of non-adults reported with disease and multiple general stress indicators, the non-adult hospital population as a whole is considered here. Where the data was sufficient, chi-square analysis was used to determine if a relationship existed between the presence of a disease and multiple stress indicators. Of the 16 non-adults reported with Vitamin D deficiency rickets, none exhibited multiple stress indicators. A total of four (26.7%) of the 15 non-adults who experienced scurvy, were also reported with two general stress indicators although none exhibited all three.

Table 5.6.8 shows that a higher proportion of non-adults with the infectious diseases stated, displayed multiple general stress indicators than the whole non-adult population. Statistically significant ($p = <0.05$) differences were found between the presence of two stress indicators and non-adults observed with or without tuberculosis (χ^2 (1, n = 1,414) = 4.434, p = 0.035) and those reported with or without endocranial lesions (χ^2 (1, n = 1,414) = 4.788, p = 0.029). However, as noted above (Section 5.6.1.2), subperiosteal new bone formation is a diagnostic indicator of certain infectious diseases, and therefore any relationship between the presence of infectious disease and multiple general stress indicators, needs to be considered with caution.

Table 5.6.8 Number and percentages of non-adults recorded with two or three general stress indicators by infectious diseases.

	Two General Stress Indicators		Three General Stress Indicators	
Infectious Disease	Number	%	Number	%
Leprosy (n = 24)	6	25.0	5	20.8
Sinusitis (n = 18)	7	38.9	3	16.7
Tuberculosis (n = 33)	11	33.3	5	15.2
Endocranial Lesions (n = 41)	13	31.7	2	4.9

The occurrence of multiple general stress indicators was also found to be proportionately higher in non-adults with Schmorl's nodes, than within the whole non-adult population (Table 5.6.9). This difference was statistically significant (p = <0.05) in relation to the presence of two stress indicators (χ^2 (1, n = 1,414) = 11.738, p = 0.001), although there was insufficient data to test using chi-square for the presence of three stress indicators.

Table 5.6.9 Number and percentages of non-adults recorded with two or three general stress indicators by joint disease.

	Two General Stress Indicators		Three General Stress Indicators	
Joint Disease	Number	%	Number	%
Schmorl's nodes (n = 110)	33	30.0	9	8.2

As shown in Table 5.6.10, nearly one-third of non-adults recorded with different dental conditions, exhibited two general stress indicators. In each instance this was a higher proportion than was found within the non-adult population as a whole (19.1%). Yet, a statistically significant difference (p = <0.01) for the presence of two stress indicators and a dental disease was only established for calculus (χ^2 (1, n = 964) = 13.198, p = 0.000). Figure 5.6.2 illustrates that a higher proportion of non-adults with dental conditions were recorded exhibiting all three general stress indicators, than the average for the non-adult population (3.3%). In this instance, statistically significant differences (p = <0.01) were found between the non-adults with all three stress indicators and those reported with or without calculus (χ^2 (1, n =

964) = 13.198, p = 0.000), caries (at the p = <0.05 value) (χ^2 (1, n = 964) = 4.811, p = 0.028), and periodontal disease (χ^2 (1, n = 964) = 12.565, p = 0.000).

Table 5.6.10 Number and percentages of non-adults recorded with two or three general stress indicators by dental conditions.

	Two General Stress Indicators		Three General Stress Indicators	
Dental Condition	Number	%	Number	%
Abscess (n = 43)	14	32.6	3	7.0
Calculus (n = 797)	240	30.1	44	5.5
Caries (n = 318)	93	29.2	22	6.9
Dental Anomalies (n = 212)	65	30.7	13	6.1
Periodontal Disease (n = 184)	60	32.6	18	9.8

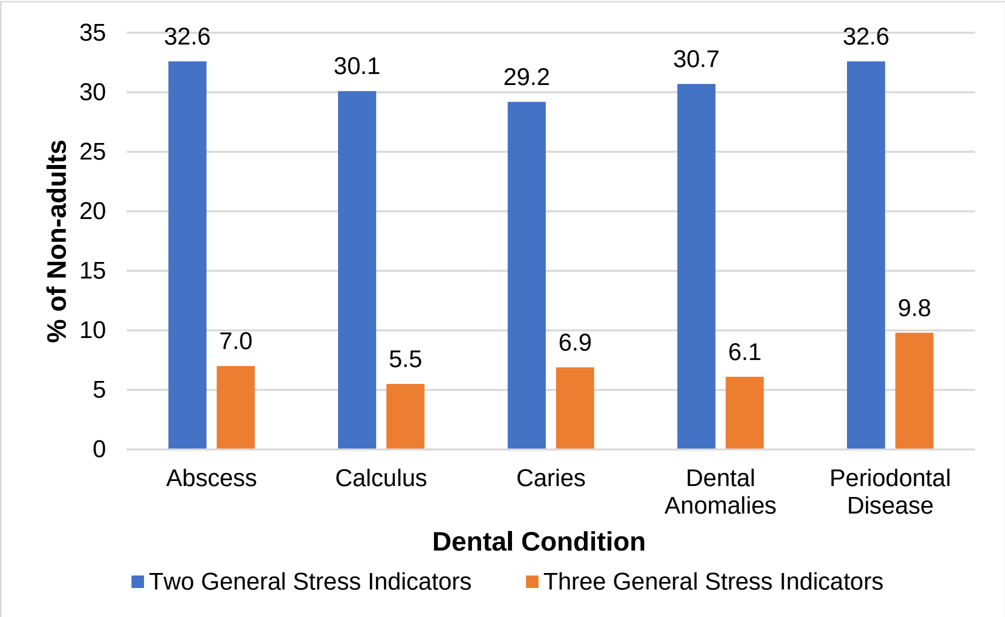


Figure 5.6.2 Percentages of non-adults recorded with two or three general stress indicators by dental conditions.

5.6.3 Co-occurrence of General Stress Indicators

The co-occurrence of general stress indicators was tested using chi-square to assess whether the presence of one stress indicator would make it more likely for a non-adult to also exhibit a different stress indicator. As shown in Table 5.6.11, approximately 5% of non-adults in Groups A, B, and C were recorded with both cribra orbitalia and subperiosteal new bone formation, and similar proportions exhibited both subperiosteal new bone formation and dental enamel hypoplasia (DEH). Differing rates of non-adults were recorded with cribra orbitalia and DEH, with the lowest proportion observed in Group B, and the highest in Group A (Figure 5.6.3).

Non-adults who exhibited cribra orbitalia were statistically significantly more likely to also have subperiosteal new bone formation, within all three groups ($p = <0.05$): Group A (χ^2 (1, n = 1,414) = 7.510, p = 0.006), Group B (χ^2 (1, n = 381) = 4.369, p = 0.037), and Group C (χ^2 (1, n = 843) = 7.503, p = 0.006). A similar statistical significance was found between the presence of cribra orbitalia and DEH at the $p = <0.01$ level: Group A (χ^2 (1, n = 1,414) = 77.616, p = 0.000), Group B (χ^2 (1, n = 381) = 15.511, p = 0.000), and Group C (χ^2 (1, n = 843) = 53.431, p = 0.000). Finally, a statistical significance was identified between the observation of subperiosteal new bone formation and DEH in Groups B ($p = <0.05$): (χ^2 (1, n = 381) = 9.338, p = 0.002) and C (χ^2 (1, n = 843) = 9.146, p = 0.002), although the chi-square test result was insignificant for Group A (χ^2 (1, n = 1,414) = 1.721, p = 0.190). With the exception of the final test, these results indicate that a non-adult who developed one general stress indicator was more likely to exhibit a second different stress indicator.

Table 5.6.11 Numbers and percentages of non-adults recorded with two general stress indicators by combination of stress indicators in Groups A, B, and C.

Combination of Stress Indicators Present	**Group A (n = 1,414)**		**Group B (n = 381)**		**Group C (n = 843)**	
	Number	%	Number	%	Number	%
Cribra Orbitalia and Subperiosteal New Bone Formation	80	5.7	18	4.7	45	5.3
Cribra Orbitalia and DEH	247	17.5	23	6.0	104	12.3
Subperiosteal New Bone Formation and DEH	82	5.8	18	4.7	50	5.9

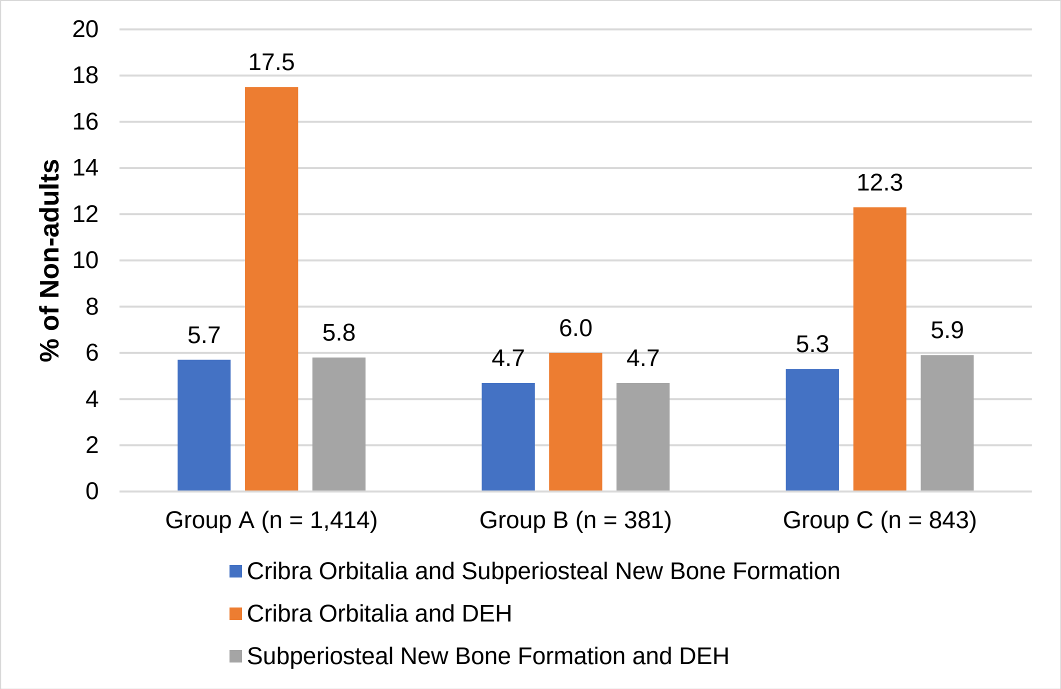


Figure 5.6.3 Percentages of non-adults recorded with two general stress indicators by combination of stress indicators in Groups A, B, and C.

5.6.4 Summary

Instances of multiple stress indicators were found to be lower in younger juveniles, and increase with age, with higher proportions of older juveniles exhibiting multiple stress indicators, and the greatest proportion reported in adolescents. In Group A, stress indicators were reported in a smaller proportion of non-adults from marginal hospitals than urban hospitals. Non-adults with one or multiple general stress indicators were typically found to have higher incidences of infectious, joint, and dental disease than non-adults who were not recorded with general stress indicators. Finally, non-adults with one stress indicator were more likely to exhibit one of the other two stress indicators.

5.7 Trauma

A total of 82 (5.8%) non-adults, from nine medieval hospital sites, exhibited at least one type of trauma on their skeletal remains. As shown in Table 5.7.1, fractures account for the majority of reported trauma, followed by osteochondritis dissecans. The remaining types of traumas were observed in eight or fewer non-adults. A total of three non-adults were interpreted as having experienced soft tissue trauma, which can be identified on the skeleton by the manifestation of an irregular bony projection (Mays, 2010a). The questions and hypotheses 11 – 14 (Appendix 3) are examined within this section. Any relationships between the presence of trauma and non-adults within certain age categories are explored, and the location types of hospitals where non-adults with trauma were identified. The co-existence or co-occurrence of trauma and disease or general stress indicators are examined as this could potentially indicate social or cultural factors, or suggest a biological frailty, which increased a non-adults risk of acquiring both disease and trauma.

Table 5.7.1 Numbers and percentages of trauma reported in Groups A, B, and C

	Group A (n = 1,414)		**Group B (n = 381)**		**Group C (n = 843)**	
Trauma	Number	%	Number	%	Number	%
Avulsion Injury	6	0.4	0	0.0	2	0.2
Blunt Force Injury	4	0.3	0	0.0	1	0.1
Dental Trauma	8	0.6	3	0.8	5	0.6
Fracture	36	2.5	8	2.1	19	2.3
Osteochondritis Dissecans	32	2.3	8	2.1	19	2.3
Perthes Disease	1	0.1	0	0.0	0	0.0
Sharp Force Injury	3	0.2	3	0.8	3	0.4
Soft Tissue Trauma	3	0.2	0	0.0	3	0.4

The anatomical location of each fracture was recorded in osteology reports. Although the type of fracture was reported for many, but not all, of the individuals examined in this research. Similarly, the status of a fracture as 'healed' was recorded by some osteologists, indicating that the fractured bone had time to unite prior to death. Two non-adults were observed with 'unhealed' rib fractures, suggesting these fractures occurred perimortem. Most non-adults recorded with a trauma were observed with a single trauma, only two non-adults were reported with multiple traumas, and both exhibited two fractures. Hence, whilst a total of 36 non-adults were reported with fractures, the number of fractures recorded by skeletal location sum to 38 (Table 5.7.2).

Table 5.7.2 Numbers and percentages of fractures recorded by skeletal location, status as healed, and type of fracture.

Fracture Location	No. Reported		Healed		Unhealed		Type
	No.	%	No.	%	No.	%	
Skull	7	0.5	4	57.1	0	0.0	Depressed fracture (n = 3), pathological fracture (n = 1)
Upper Long Bone	5	0.4	5	100.	0	0.0	Green stick fracture (n = 2), supracondylar (n = 1)
Lower Long Bone	5	0.4	4	80.0	0	0.0	Green stick fracture (n = 1), stress fracture (n = 1), transverse fracture (n = 1)
Spine	4	0.3	0	0.0	0	0.0	Compression fracture (n = 3)
Rib	6	0.4	4	66.7	2	33.3	Oblique fracture (n = 1), transverse fracture (n = 2)
Joint	2	0.1	1	50.0	0	0.0	Stress fracture (n = 1)
Hand	4	0.3	4	100.	0	0.0	Compression fracture (n = 1), oblique fracture (n = 1)
Foot	5	0.4	5	100.	0	0.0	Compression fracture (n = 2), green stick fracture (n = 1), transverse fracture (n = 1)

5.7.1 Trauma and Age

Trauma was explored by age category to identify trends in the pattern of trauma occurrence. As shown in Table 5.7.3, in Group A, B, and C, the incidence of trauma increased with age and this was statistically significant in each group at the p = <0.01 level: Group A (χ^2 (2, n = 1,414) = 34.300, p = 0.000), B (χ^2 (2, n = 381) = 13.875, p = 0.001) and C (χ^2 (2, n = 843) = 26.470, p = 0.000). As opportunities to experience trauma increase with age, this pattern is to be reasonably expected.

Table 5.7.3 Numbers and percentages of non-adults recorded with trauma by age category in Groups A, B, and C.

Age Category	Group A (n = 1,414)		Group B (n = 381)		Group C (n = 843)	
	Number	%	Number	%	Number	%
Younger Juvenile	3	0.2	3	0.8	3	0.4
Older Juvenile	16	1.1	4	1.0	9	1.1
Adolescent	63	4.5	12	3.1	34	4.0
Total	82	5.8	19	5.0	46	5.5

Of the three younger juveniles who experienced trauma, two were reported with dental trauma and one exhibited a fracture to the skull. Avulsion injuries, the sole occurrence of Perthes disease, and the three soft tissue injuries were all reported in adolescents. Figure 5.7.1 illustrates that the pattern for overall trauma by age category, is also found when fractures and osteochondritis dissecans are examined by age category: rates are higher in adolescents than in juveniles. The data in Group A were sufficient to conduct statistical analysis, and the difference in the rate of fractures (χ^2 (2, n = 1,414) = 12.219, p = 0.002) (p = <0.05) and osteochondritis dissecans (χ^2 (2, n = 1,414) = 17.763, p = 0.000) (p = <0.01) by age category were statistically significant. Notably, the older juveniles exhibiting osteochondritis dissecans were from St Mary Spital, London. As with the general risk of acquiring a traumatic injury, osteochondritis dissecans is associated with the increased activity of adolescents and therefore this finding is as reasonably expected.

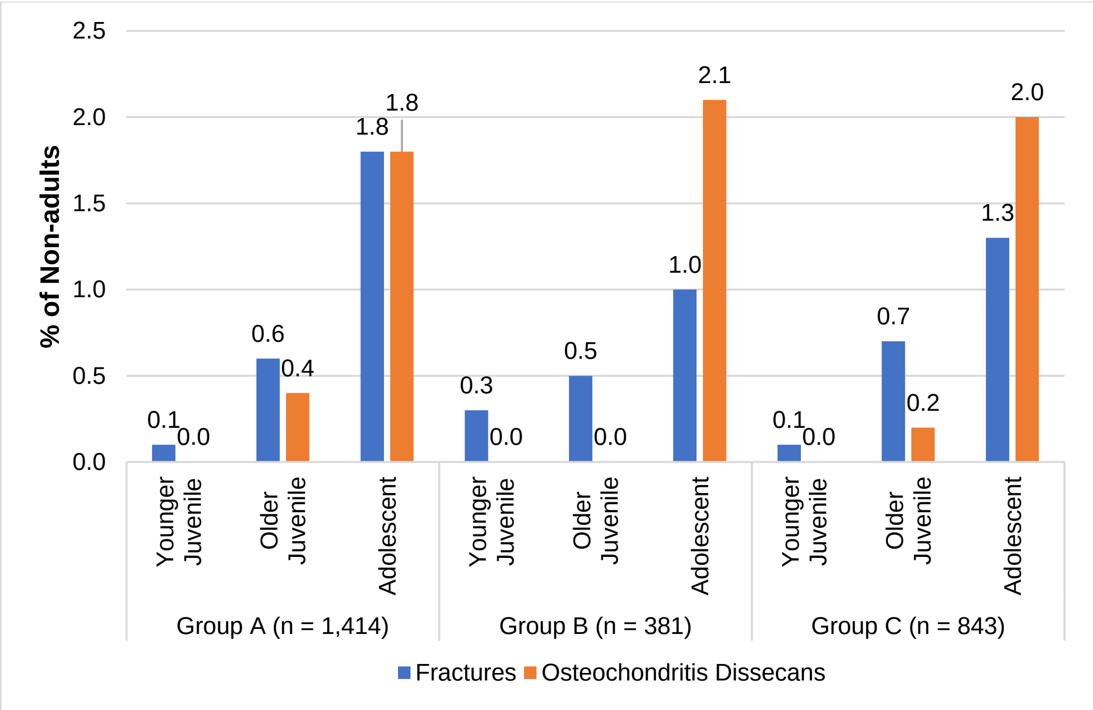


Figure 5.7.1 Percentages of non-adults recorded with fractures or osteochondritis dissecans by age category in Groups A, B, and C.

5.7.2 Trauma and Hospital Location

Trauma was explored by hospital location to identify if non-adults from a particular type of hospital location were more or less likely to have experienced trauma, than non-adults from a different hospital location. As can be seen in Table 5.7.4, most traumas reported in Group A were identified from urban locations, yet in Group B only a single incidence of trauma was observed on a non-adult from an urban hospital. This illustrates that the majority of non-adults from urban hospitals who exhibited trauma were buried at St Mary Spital, London. Rates of trauma reported from marginal sites are therefore lower than those from urban sites in Group A, but greater than in Group B. The differences in the proportions of non-adults exhibiting traumas from urban hospitals in Group C and marginal sites vary by each trauma. Of the 16 non-adults identified at rural hospitals, a single non-adult with osteochondritis dissecans was reported.

The Group A data was analysed using chi-square to determine if the differences in the presence of overall trauma (χ^2 (2, n = 1,414) = 0.577, p = 0.750), fractures (χ^2 (2, n = 1,414) = 0.384, p = 0.825), or osteochondritis dissecans (χ^2 (2, n = 1,414) = 1.196, p = 0.550) by hospital location were significant, however in each instance the results were statistically insignificant (p = <0.05).

Table 5.7.4 Numbers and percentages of types of traumas recorded by hospital location.

Trauma	**Group A Urban (n = 1,145)**		**Group B Urban (n = 112)**		**Group C Urban (n = 574)**		**Marginal (n = 253)**		**Rural (n = 16)**	
	No.	%	No.	%	No.	%	No.	%	No.	%
Avulsion Injury	6	0.5	0	0.0	2	0.3	0	0.0	0	0.0
Blunt Force Injury	4	0.3	0	0.0	1	0.2	0	0.0	0	0.0
Dental Trauma	5	0.4	0	0.0	2	0.3	3	1.2	0	0.0
Fracture	28	2.4	0	0.0	11	1.9	7	2.8	0	0.0
Osteochondritis Dissecans	25	2.2	1	0.9	12	2.1	6	2.4	1	6.25
Perthes Disease	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0
Sharp Force Injury	0	0.0	0	0.0	0	0.0	3	1.2	0	0.0
Soft Tissue Trauma	3	0.3	0	0.0	3	0.5	0	0.0	0	0.0

5.7.3 Trauma and Disease

The co-existence or co-occurrence of trauma and disease were considered to explore any potential relationship between trauma and the influence of disease and lifestyle factors (for example diet) on the body. Some diseases can impact bone density and increase an individual’s likelihood of sustaining trauma. Additionally, certain work roles may be a common denominator in increasing an individual’s risk of acquiring joint disease and also experiencing trauma. In this section, due to the low number of non-adults reported with both trauma and a disease, the non-adult population is considered in its entirety. The rates of non-adults recorded with trauma and a particular disease are compared with the proportion of non-adults who were recorded with the disease but not with trauma. However, the observation of trauma is dependent on levels of skeletal completeness and preservation, and it is therefore likely that more non-adults sustained trauma than are recorded. General stress indicators and trauma are considered below in Section 5.7.4.

As shown in Table 5.7.5, two non-adults were reported with both trauma and Vitamin D deficiency rickets, both of whom had sustained a fracture. No non-adults with Vitamin C deficiency scurvy were observed with trauma, however the numbers recorded are small. Consequently, it is not possible to draw any conclusions about the relationship between these metabolic conditions and trauma.

Table 5.7.5 Numbers and percentages of non-adults recorded with traumas and metabolic diseases.

	All Trauma (n = 82)		**Fracture (n = 36)**		**Osteochondritis Dissecans (n = 32)**	
Metabolic Disease	Number	%	Number	%	Number	%
Vitamin D deficiency Rickets (n = 16)	2	2.4	2	5.6	0	0.0
Vitamin C deficiency Scurvy (n = 15)	0	0.0	0	0.0	0	0.0

A total of 25 of non-adults were recorded with both trauma and an infectious disease and the numbers for individual infectious diseases and trauma are small (Table 5.7.6). The proportions of non-adults reported with both trauma and leprosy was higher than the proportion of non-adults who were not observed with trauma but who were reported with leprosy (1.4%). This may be due to the symptoms of leprosy which can increase an individual’s risk of sustaining trauma (Rawcliffe, 2006). The rates of non-adults exhibiting endocranial lesions was also higher for those reported with trauma, and specifically fractures, compared to non-adults who were not observed with trauma (2.8%). Yet, the rates of non-adults recorded with both endocranial lesions and osteochondritis dissecans were similar to those who did not exhibit osteochondritis dissecans (2.9%).

Table 5.7.6 Numbers and percentages of non-adults recorded with traumas and infectious diseases.

	All Trauma (n = 82)		**Fracture (n = 36)**		**Osteochondritis Dissecans (n = 32)**	
Infectious Disease	Number	%	Number	%	Number	%
Leprosy (n = 24)	5	6.1	2	5.6	3	9.4
Sinusitis (n = 18)	1	1.2	0	0.0	1	3.1
Tuberculosis (n = 33)	2	2.4	2	5.6	0	0.0
Endocranial Lesions (n = 41)	4	4.9	2	5.6	1	3.1

In relation to joint disease, the proportion of non-adults who were recorded with Schmorl's nodes is notably greater in those who exhibited trauma compared to non-adults who were not recorded with trauma (Table 5.7.7 and Figure 5.7.2). This difference was statistically significant (χ^2 (1, n = 1,414) = 24.369, p = 0.001) at the p = <0.01 level. However, age may be an influential factor in these differences, as 97.3% (107/110) of non-adults reported with Schmorl's nodes were adolescents, and this age group was also recorded with the greatest proportion of traumas (76.8%, 63/82).

Table 5.7.7 Numbers and percentages of non-adults recorded with traumas and Schmorl's nodes.

	All Trauma (n = 82)		**Fracture (n = 36)**		**Osteochondritis Dissecans (n = 32)**	
Joint Disease	Number	%	Number	%	Number	%
Schmorl's nodes (n = 110)	18	22.0	6	16.7	6	18.8

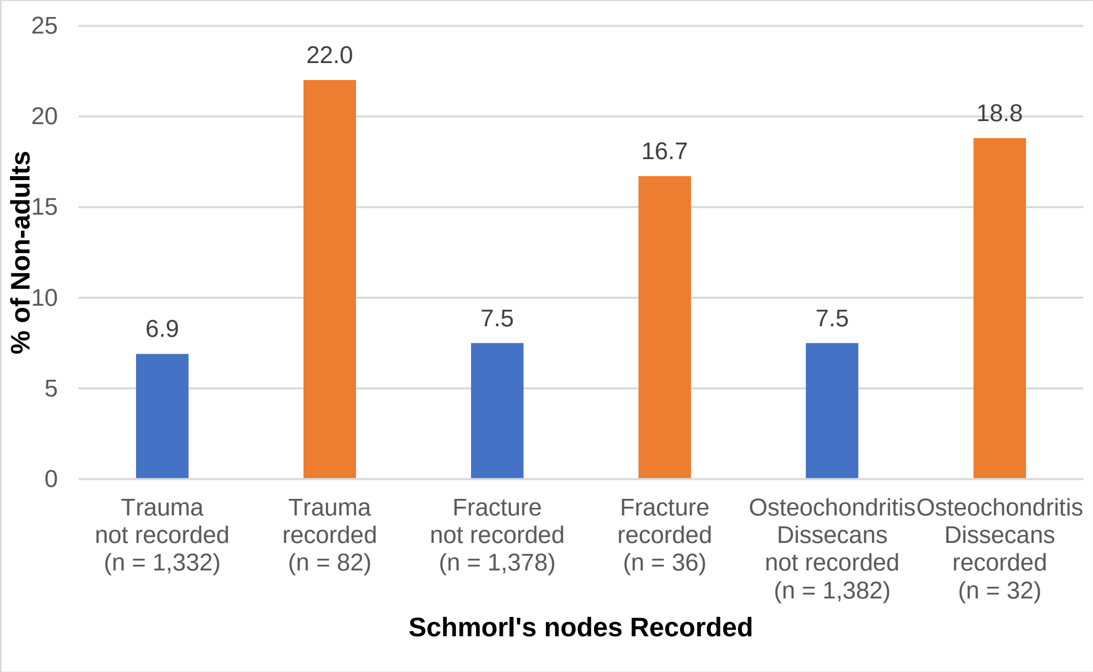


Figure 5.7.2 Percentages of non-adults recorded with Schmorl's nodes (n = 110) by non-adults recorded with or not recorded with traumas.

Table 5.7.8 shows the proportions of non-adults reported with trauma who also exhibited dental disease. With the exception of caries, the proportion of non-adults exhibiting dental conditions are greater for those reported with trauma, and specifically with fractures or osteochondritis dissecans, than in non-adults who were not recorded with trauma. These differences were found to be statistically significant in relation to calculus (χ^2 (1, n = 1,414) = 16.018, p = 0.000) (p = <0.01), and at the p = <0.05 value for dental anomalies (χ^2 (1, n = 1,414) = 4.829, p = 0.028) and periodontal disease (χ^2 (1, n = 1,414) = 10.353, p = 0.001). Age may again be an influential factor, as the prevalence of both trauma and dental conditions typically increase with age, and there is a positive correlation between these variables, as illustrated in Figure 5.7.3. As the non-adult population who did not exhibit trauma includes a higher number of juveniles than the population reported with trauma, it may be reasonably expected that levels of dental disease would be higher within the mainly adolescent non-adults who exhibited trauma.

Table 5.7.8 Numbers and percentages of non-adults recorded with traumas and dental conditions.

	All Trauma (n = 82)		Fracture (n = 36)		Osteochondritis Dissecans (n = 32)	
Dental Condition	Number	%	Number	%	Number	%
Abscess (n = 43)	7	8.5	3	8.3	0	0.0
Calculus (n = 797)	64	78.0	26	72.2	26	81.3
Caries (n = 318)	17	20.7	6	16.7	6	18.8
Dental Anomalies (n = 212)	19	23.2	7	19.4	8	25.0
Periodontal Disease (n = 184)	20	24.4	7	19.4	6	18.8

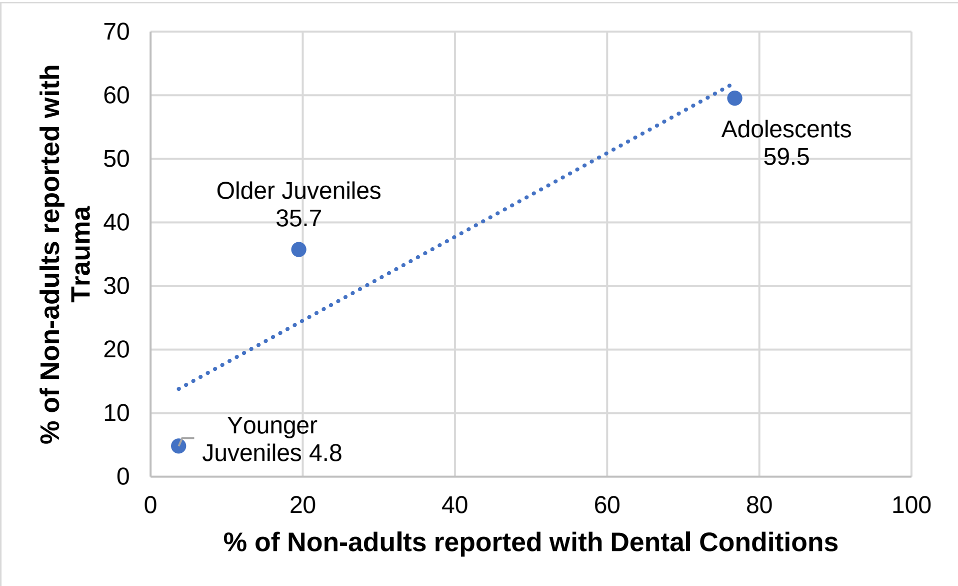


Figure 5.7.3 Percentages of non-adults reported with trauma and dental conditions by age category.

5.7.4 Trauma and General Stress Indicators

Table 5.7.9 and Figure 5.7.4 show that non-adults reported with trauma were recorded with higher rates of cribra orbitalia and subperiosteal new bone formation than non-adults who did not exhibit trauma (31.8% and 13.2%, respectively). A similar pattern was observed in the differences of those reported with fractures and osteochondritis dissecans. Although, the rates of cribra orbitalia in those observed with or without a fracture were similar (32.4% and 30.6%, respectively). The difference in the proportion of non-adults reported with or without trauma yet observed with subperiosteal new bone formation (χ^2 (1, n = 1,414) = 8.082, p = 0.004) was statistically significant (p = <0.05). Yet, the body's reaction to trauma is to form new bone, and as such, it is reasonable to expect a higher rate of subperiosteal new bone formation reported for non-adults who experienced trauma. Rates of dental enamel hypoplasia were proportionally lower or similar in non-adults reported with and those recorded without trauma overall, fractures or osteochondritis dissecans. Chi-square tests demonstrate that any differences in the presence of cribra orbitalia and trauma (χ^2 (1, n = 1,414) = 2.499, p = 0.114), and of DEH and trauma (χ^2 (1, n = 1,414) = 1.142, p = 0.285) were not statistically significant at the p = <0.05 value.

Table 5.7.9 Numbers and percentages of non-adults recorded with traumas and general stress indicators.

General Stress Indicator	**All Trauma (n = 82)**		**Fracture (n = 36)**		**Osteochondritis Dissecans (n = 32)**	
	Number	%	Number	%	Number	%
Cribra Orbitalia (n = 457)	33	40.2	11	30.6	13	40.6
Subperiosteal New Bone Formation (n = 196)	20	24.4	7	19.4	6	18.8
Dental Enamel Hypoplasia (n = 532)	36	43.9	13	36.1	15	46.9

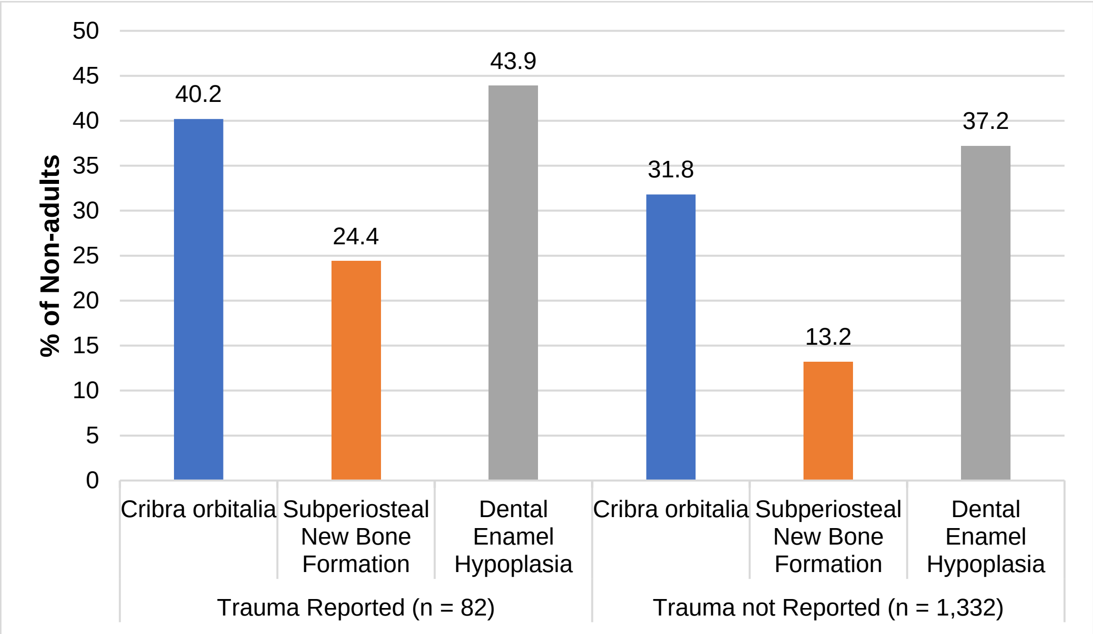


Figure 5.7.4 Percentages of non-adults recorded with general stress indicators by reported trauma.

5.7.5 Summary

Incidents of trauma were found to be lower in younger and older juveniles, but significantly higher in adolescents. Most non-adults who exhibited trauma were recorded from St Mary Spital, London, although this could be related to the large scale of the archaeological excavation conducted at the site or aspects of life in medieval London, which increased the risk of sustaining trauma. The data also shows that typically, non-adults with certain infectious diseases, joint disease, dental disease, and general stress indicators, had higher rates of trauma than was observed in non-adults without evidence of disease or stress indicators. However, this may be related to age, as stated above, most non-adults who exhibited trauma were adolescents and this age group were also more likely to have experienced joint and dental disease.

5.8 Burial Practices

The questions and hypotheses 15 – 17 (Appendix 3) are tested in this section, to examine if any relationship existed between age and the use of coffins for burial, and whether hospitals in certain location types favoured the use of coffins. Most coffin burials were reported from a single site, St James and St Mary Magdalene, Chichester, which was founded as a leprosarium. Therefore, coffined burial in relation to the reporting of leprosy is also explored to identify whether any relationship existed between these two factors. Other aspects of burial practices, including multiple burials and the location of non-adult burials within cemeteries are also considered.

Within archaeological reports employed in this study, the use of coffins for burial was primarily interpreted through the presence of coffin nails within the grave cut (Price and Ponsford, 1998; Magilton *et al*., 2008). Additional methods of identifying the use of coffins included soil stains (Clough and Witkin, 2006) and the parallel-sided position of human remains which suggested the bodies were confined within a box (McComish *et al*., 2017). Whilst the majority of non-adults were not buried in a coffin, this evidence suggests a total of 97 (6.4%) non-adults were buried in coffins at hospital sites.

In total, 17 objects or stain marks, indicating the former presence of an object, potentially related to burial practices, were identified in non-adult burials at five hospital sites. These include a copper alloy lace tag and a possible buckle plate from a grave at St Leonard's, Peterborough. 'Ear-muffs' were identified in nine burials and a possible lace tag was found in an additional burial at St James and St Mary Magdalene, Chichester. An iron oval framed buckle was recorded in a single grave at St Nicholas, Lewes, two peg tiles and pottery fragments were found within three graves at Crouched Friars, Colchester. A copper stain on a frontal cranial bone of one individual was interpreted by excavators as indicating the presence of a shroud pin at St John the Baptist, Lichfield (Goacher *et al*., 2016).

5.8.1 Coffined Burials and Age

No coffin burials were identified at St Mary Spital, London. This may reflect differing burial practices within hospitals in London, compared to hospitals in smaller towns or rural areas. Due to this, the data for Group B non-adults (n = 436), which excludes the St Mary Spital data, is used in this section.

The majority of non-adults within Group B were not afforded a coffin burial (n = 339, 77.8%). Of the 97 non-adults for whom coffin burials were indicated during archaeological excavation, Table 5.8.1 shows that when six age categories are used, older juveniles were given the highest number of coffined burials. However, when the age categories within the younger juvenile age group are combined, they total 59, and the use of coffins therefore declines with the older age groups, with fewer adolescents given coffined burials. The difference in the use of coffin burials for younger juveniles and adolescents is statistically significant (χ^2 (2, n = 432) = 27.721, p = 0.000) at the p = <0.01 value. Figure 5.8.1 illustrates that within each age category, coffin burials were used proportionately more frequently for perinates. Although, the total number of perinates is very small and the three which were afforded a coffin burial were all from the single site of St James and St Mary Magdalene, Chichester, and may reflect burial customs at this particular hospital. The rates of coffin burial within the neonate, infant, and child age categories are notably similar and no statistical significance (p = <0.05) (χ^2 (2, n = 158) = 0.122, p = 0.941) was found for coffined burials between these age groups.

Table 5.8.1 Numbers and percentages of non-adults given a coffined burial by age category.

Age Category	Number	%
Perinate (n = 4)	3	0.7
Neonate (n = 38)	14	3.2
Infant (n = 55)	19	4.4
Child (n = 66)	23	5.3
Older Juvenile (n = 139)	24	5.5
Adolescent (n = 123)	14	3.2
Non-adult <18 years (n = 11)	0	0.0

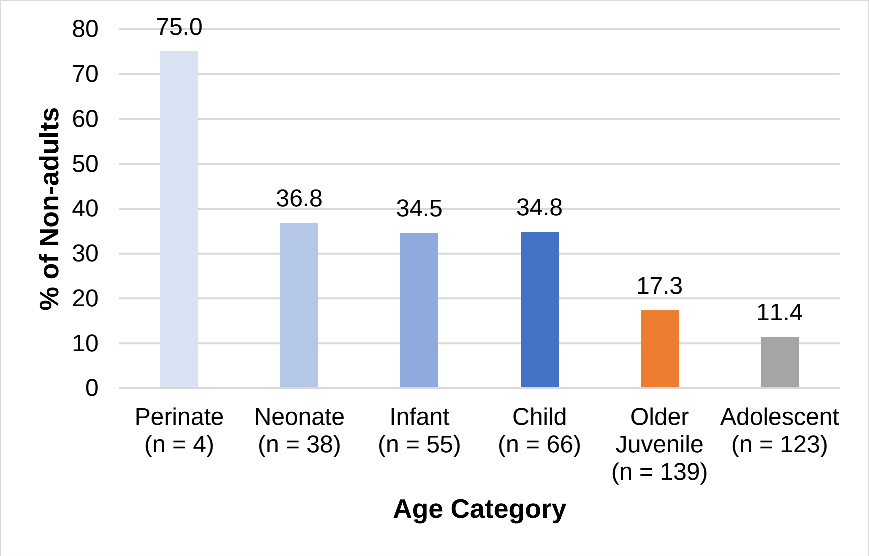


Figure 5.8.1 Percentage of non-adults given a coffin burial within each age category.

5.8.2 Coffined Burials and Hospital Location

Coffined burials were recorded at six hospitals: a total of eight from three general hospitals in urban locations, and 89 were reported from three hospitals founded as leprosaria in marginal locations. None of the burials for the 16 non-adults from rural sites were interpreted as using coffins. Table 5.8.2 shows that at four of the six hospitals, 20% to 30% of the non-adults identified, were buried in a coffin. Although, at each site, comparatively few non-adults were reported. The difference in the occurrence of coffin burial by hospital location was statistically significant (p = <0.01) (χ^2 (5, n = 436) = 84.116, p = 0.000). This may be explained by the much higher number of non-adults from St James and St Mary Magdalene, Chichester, who were recorded as being given a coffin burial.

Table 5.8.2 Numbers and percentages of non-adults given a coffin burial by hospital location.

Urban Hospitals	**Number**	**% of non-adult coffined burials by site**
St Bartholomew, Bristol	2	28.6
St Bartholomew, Newbury	5	20.0
St Mary Magdalene, Bawtry	1	2.9
Marginal Hospitals	**Number**	**% of non-adult coffined burials by site**
St Leonard's, Peterborough	2	28.6
St Mary Magdalene, Winchester	8	20.0
St James and St Mary Magdalene, Chichester	79	75.2

5.8.3 Coffined Burials and Phased Sites

The data for coffined burials and phased sites were too small to conduct statistical tests. Of the five sites where burials were phased, only St Leonard's, Peterborough, and St James and St Mary Magdalene, Chichester, contained evidence for coffined burials. St Leonard's is phased into two periods, from the AD 11th-13th century and from the AD 13th-17th century. Of the seven non-adults recorded from this site, two were buried within a coffin, and both individuals date to the second phase of the cemetery. Of the 105 non-adults identified at St James and St Mary Magdalene, 79 (75.2%) of these individuals were interpreted as having coffined burials. The cemetery was divided into three undated phases: the highest proportion of coffined burials occurs in the first cemetery phase (74/93, 79.6%), when the hospital was a leprosarium. The use of coffins then declines in the second phase (2/7, 28.6%), before increasing again in the final phase (3/4, 75.0%), although comparatively few non-adults were identified in these later phases which makes comparisons with the first phase questionable.

5.8.4 Coffined Burials and Leprosy

As the majority of coffined burials were identified at hospitals which were founded as leprosaria, any relationship between the use of coffins and non-adults reported with leprosy, was explored using chi-square analysis. Of the 24 non-adults who exhibited skeletal indicators of leprosy, four were given coffined burials: one from St Leonard's, Peterborough, and three from St Mary Magdalene, Winchester. The result of the chi-square test (χ^2 (1, n = 381) = 1.043, p = 0.307) demonstrates that, at the p = <0.05 level, there is no statistically significant association between coffined burials and non-adults with leprosy.

5.8.5 Burials Containing 'Ear-muffs'

'Ear-muff's' is a term used to describe a pair of stones placed during burial on either side of an individual's head. This pattern of stone placement was identified in nine non-adult burials, all at the hospital of St James and St Mary Magdalene, Chichester. Table 5.8.3 states the ages given in the osteology report for the non-adults buried with 'ear-muff's', of the nine non-adults four were younger juveniles, four were older juveniles, and a single adolescent burial involved this practice. Most of the burials which included 'ear-muff's' were also interpreted as being coffined burials.

Table 5.8.3 Non-adults reported with 'ear-muff's' at the hospital of St James and St Mary Magdalene, Chichester.

Skeleton Number (from osteology report)	Age (Years)	Evidence of a Coffin
Sk188	2	No
Sk200	12	Yes
Sk206	5	Yes
Sk220	7	Yes
Sk226	11	Yes
Sk237	7	Yes
Sk249	6	Yes
Sk281	1	Yes
Sk308	5	Yes

5.8.6 Types of Graves

Of the 1,506 non-adults included in this current research, the method of burial of 79 were not recorded, and the bones of 45 non-adults were found disarticulated or co-mingled with other individuals. Table 5.8.4 shows that most non-adults were buried within single, individual graves, as was the common practice in medieval England. Yet, the second highest number of non-adults were buried in mass graves located within the cemetery of St Mary Spital, London. Also, from St Mary Spital, 119 individuals were categorised as being buried side-by-side in single layer horizontal graves, and 52 non-adults were buried in vertical 'stacked' graves with one individual placed on top of another. Vertical stacking of graves was recorded at one other site, namely St Bartholomew, Newbury, where a 7 to 8.5-year-old was identified. This individual was buried within a vertical stack of three individuals which also included a young adult female and a second adult female (Clough and Witkin, 2006).

Table 5.8.4 Numbers and percentages of non-adults by type of burial.

Type of Burial	Number	%
Individual Grave	618	41.0
Mass Grave	571	37.9
Multiple Horizontal Grave	119	7.9
Multiple Vertical Grave	52	3.5
Double or Multiple Burial	19	1.3
Disarticulated or Co-mingled	45	3.0
Not recorded	82	5.4

A total of 19 non-adults were recorded as being buried in double or multiple burials. Within four of these burials, two non-adults were interred, and thirteen of them also contained an adult. Table 5.8.5 shows the hospital locations where multiple burials were identified and where the information was available, the age and sex of the non-adults and the adults they were buried with.

Table 5.8.5 Double and multiple burials identified at medieval hospital sites.

Hospital Site	Non-adults	Adults	Notes	Reference
St Bartholomew, Bristol	16-18 years old, possible male (Sk30)	Two adults, possibly female	None	Price and Ponsford (1998)
St Bartholomew, Bristol	6-8 years old (Sk44)	Adult male +45 years old (Sk43)	Sk43 buried in a coffin	Price and Ponsford (1998)
St Bartholomew, Newbury	7-8.5 years old (Sk68)	Two adult females, 18-24 years old and 35-40 years old	Vertical stack burial	Clough and Witkin (2006)
St John the Evangelist, Cambridge	11-15 years old (Sk4111), 6-10 years old (Sk4112)	Mature adult male, possible mature adult female	Located outside the cemetery boundary	Cessford (2012)
St John the Evangelist, Cambridge	11-15 years old (Sk7044)	Elderly male	None	Cessford (2012)
St Nicholas, Lewes	18 months old infant (Sk271)	Adult male	Possible double burial in chalk cut grave	Barber and Sibun (2010)

Hospital Site	Non-adults	Adults	Notes	Reference
Crouched Friars, Colchester	3-5 years old	Adult	None	Benfield and Brooks (2007)
Crouched Friars, Colchester	<20 years old	>20 years old	None	Benfield and Brooks (2007)
St Margaret's, Gloucester	14-15 years old (Sk2)	Adult male 36-45 years old, adult female	Sk2 buried in-between the adults	Evans (2006)
St John the Baptist, Berkhamsted	Juvenile (Sk1003)	Individual, age and sex unknown	None	Maher (2014)
St Mary Magdalene, Bawtry	14-16 years old, possible male (Sk1025),1-2 years old (Sk1038)	None	None	McIntyre and Hadley (2012)
St James and St Mary Magdalene, Chichester	43 weeks old (Sk67a), 1.5 years old (Sk67b)	None	None	Magilton *et al*. (2008)
St James and St Mary Magdalene, Chichester	Older child (Sk113b)	Two adult males	None	Magilton *et al*. (2008)
St James and St Mary Magdalene, Chichester	10.6-14.5 years old (Sk130b), 6.6-10.5 years old (Sk170)	Adult, possibly male	Sk130b buried in a coffin	Magilton *et al*. (2008)
St James and St Mary Magdalene, Chichester	11 years old (Sk313a)	Mature adult female, young adult male	Sk313a buried in a coffin	Magilton *et al*. (2008)

5.8.7 Location of Burials

Most non-adult burials (n = 1,487, 98.7%) identified at medieval hospital sites were located within hospital cemeteries, or in areas interpreted by the excavator as likely to be part of a cemetery. A total of 19 non-adults were buried within chapel buildings, detailed in Table 5.8.6. At three of these hospitals, all of the non-adult burials were observed in chapels, which may be explained by limitations to the extent of archaeological excavation. Only two (0.1%) non-adults were located outside the cemetery boundary, and they were both reported at St John the Evangelist, Cambridge (Cessford, 2012). Four (0.3%) individuals from St Margaret, Huntingdon, were reportedly recovered from excavated spoil (Mitchell, 1993), therefore the location of their burial is unknown.

Table 5.8.6 Numbers and percentages of non-adults buried in chapels or outside cemetery areas.

Burials in Chapels	Number	% of non-adult burials by site
St Bartholomew, Bristol	7	100.0
St Mary, Castleton	2	100.0
St Mary Magdalene, Winchester	1	2.5
St Mary Spital, London	7	0.7
St Mary, York	2	100.0

Burials outside the Cemetery	Number	% of non-adult burials by site
St John the Evangelist, Cambridge	2	3.3

At three hospitals the burial of some non-adults within the cemetery appeared to be zoned, and this was interpreted by the excavators as being influenced by differing burial practices for certain age groups (Table 5.8.7). Notably younger juveniles and particularly perinates and neonates were buried in clustered areas, distinct from the usual cemetery rows. The relevance of the locations of non-adult burials within cemeteries are considered in the discussion in Chapter 6.

Table 5.8.7 Hospitals where zoning of burials by age category occurred.

Hospital	Description of Zoning
St Mary Spital, London	Perinate and neonate burials were located near a preaching cross.
St Mary Magdalene, Bawtry	Younger juveniles were buried next to the chapel wall.
St James and St Mary Magdalene, Chichester	Younger juveniles were predominantly buried near the cemetery boundary.

5.8.8 Burials with Anomalies

Burials in which the treatment or placement of the body differed from the normal medieval practices were reported from three hospitals (Table 5.8.8). Possible reasons for the different treatment in burial of these non-adults are discussed in Chapter 6.

Table 5.8.8 Hospitals where burials with anomalies were reported.

Hospital	Description of Burial
St John's, Lutterworth	A burial of an adolescent placed in a reversed position, with their head to the west.
St Mary Spital, London	A burial of an adolescent placed supine, with their skull placed between their feet.
St Peter's, Bury St Edmunds	A burial of an older juvenile reported as having cut marks on the thoracic spine and a large stone placed within the rib cage

5.8.9 Summary

The majority of coffined burials were afforded to younger juveniles whilst adolescents had comparatively fewer coffined burials. Between hospital locations, a smaller number of non-adults were buried in a coffin at urban sites in contrast to marginal hospitals, where a significantly higher proportion of non-adults were reported in coffined burials. Although the data for burial type (i.e., individual or multiple burial) and location of burials within cemeteries were not statistically tested, it was found that the majority of non-adults across all the hospital sites were buried in single graves within ordered cemetery rows. However, as discussed in Chapter 6, some individuals were buried differently, for example, within hospital chapels or as part of multiple burials.

5.9 Non-hospital Comparative Sites

Within the discussion (Chapter 6), comparisons are made between the non-adults from hospital sites and 2,523 non-adults from a total of 11 medieval non-hospital, or parish and monastic, cemetery sites (Table 5.9.1). Many of the cemeteries were in use prior to and beyond the end of the medieval period. Where these cemeteries were phased and dated to the medieval period by the excavators, only these data were used for comparative purposes. As with some of the hospital sites, not all of the skeletal remains uncovered during excavation were osteologically analysed. Hence, the minimum number of individuals (MNI) analysed are stated in Table 5.9.1 rather than the total number recorded at a given site. At certain sites, excavation or osteological analysis was undertaken at different times. For example, at St Gregory, Canterbury (Kent) a total of 1,342 individuals were recorded, with initially 91 skeletons osteologically analysed (Hicks and Hicks, 2001). An additional 104 non-adults were later analysed by Dawson (2014) for research specifically focused on non-adults from the medieval period. Further information about each cemetery site can be found in Appendix 4.

Table 5.9.1 Medieval parish and monastic cemeteries used for comparisons with the non-adult hospital population.

Site Name	**Date**	**Type of Cemetery**	**MNI Analysed**	**MNI of Non-adults**	**Percentage of Non-adults**	**Key Reference**
St Oswald, Gloucester, Gloucestershire	1120-1540	Priory and parish	280	76	27.1	Heighway and Bryant (1999)
St Gregory, Canterbury, Kent	1080-1536	Priory and parish	195	126	64.6	Hicks and Hicks (2001)
St Peter's, Barton-upon-Humber, Lincolnshire	950-1500	Parish	2,750	810	29.5	Waldron (2007)
East Smithfield, London	1348-1350	Black Death	636	177	27.8	Cowal *et al*. (2008)
St Mary Graces, London	1350-1540	Cistercian abbey	389	106	27.2	Bekvalac *et al*. (2007)
St Andrew Fishergate, York, North Yorkshire	1050-1350	Parish and priory	402	90	22.4	Stroud and Kemp (1993)
St Helen-on-the-Walls, York, North Yorkshire	950-1550	Parish	674	200	29.7	Dawes and Magilton (1980)
Wharram Percy, Malton, North Yorkshire	1066-1540	Parish	687	327	47.6	Mays (2007)
St Peter and St Paul, Taunton, Somerset	1150-1535	Priory	190	93	48.9	Dawson (2014)
Wells Cathedral. Wells, Somerset	Early medieval - 1550	Cathedral	287	45	15.7	Rogers, 2001
Stoke Quay, Ipswich, Suffolk	Late 9th – 15th c.	Parish	1,142	473	41.4	Gibson *et al*. (2020)

As shown in Table 5.9.2, the proportions of non-adults reported with a congenital disease were similar from medieval hospitals and contemporary parish and monastic sites. A higher proportion of non-adults from hospitals exhibited evidence of metabolic conditions, infectious disease, and joint disease than those from non-hospital cemeteries. Conversely, the percentage of non-adults recorded with a miscellaneous condition was lower in the hospital non-adult population than the parish and monastic population.

Table 5.9.2 Numbers and percentages of non-adults recorded with pathologies from hospitals and from parish and monastic sites.

	Hospital sites (n = 1,414)		**Parish and Monastic sites (n = 2,523)**	
Category	**Number**	**%**	**Number**	**%**
Congenital Disease	40	2.8	66	2.6
Metabolic Disease	513	36.3	598	23.7
Infectious Disease	283	20.0	323	12.8
Joint Disease	123	8.7	12	0.5
Miscellaneous Conditions	31	2.2	92	3.6

Akin to the data for hospital sites, only non-adults from parish and monastic sites with dentition were included in the osteology reports concerning dental conditions. The total number of non-adults from non-hospital sites with teeth or mandibles was 1,539. Dental conditions were reported for Stoke Quay, Ipswich as true prevalence rates that were not comparable with the crude prevalence rates recorded in other osteology reports and used in this thesis. Consequently, the data from Stoke Quay is not included here, although it is stated in Appendix 4. As shown in Table 5.9.3, the proportion of non-adults from hospitals reported with each dental disease, was notably higher than the rates recorded for non-adults from parish and monastic cemeteries.

Table 5.9.3 Numbers and percentages of non-adults recorded with dental conditions from hospitals and from parish and monastic sites.

Dental Condition	Hospital sites (n = 964)		Parish and Monastic sites (n = 1,539)	
	Number	**%**	**Number**	**%**
Abscess	43	4.5	30	1.9
Calculus	797	82.7	116	7.5
Caries	318	33.0	125	8.1
Periodontal Disease	184	19.1	7	0.5

Table 5.9.4 shows that more non-adults from hospital sites than from parish and monastic sites were reported with each of the three general stress indicators. The difference in the proportions of non-adults exhibiting subperiosteal new bone formation is the smallest at 3.2%, with the greatest disparity occurring between non-adults recorded with dental enamel hypoplasia from hospital and non-hospital sites.

Table 5.9.4 Numbers and percentages of non-adults recorded with general stress indicators from hospitals and from parish and monastic sites.

General Stress Indicator	Hospital sites (n = 1,414)		Parish and Monastic sites (n = 2,523)	
	Number	**%**	**Number**	**%**
Cribra Orbitalia	457	32.3	549	21.8
Subperiosteal new bone formation	196	13.9	270	10.7
Dental Enamel Hypoplasia	532	55.2	187/1,539	12.2

The numbers of non-adults reported exhibiting trauma was higher in those from hospital sites than parish and monastic cemeteries (Table 5.9.5). Similarly, when just fractures are considered, the rate of non-adults recorded with this type of trauma was four times greater from hospital sites than contemporary non-hospital cemeteries.

Table 5.9.5 Numbers and percentages of non-adults recorded with trauma from hospitals and from parish and monastic sites.

	Hospital sites (n = 1,414)		Parish and Monastic sites (n = 2,523)	
Trauma	**Number**	**%**	**Number**	**%**
All trauma	82	5.8	34	1.3
Fractures	36	2.5	16	0.6

One additional specific pathology considered in the following discussion is Vitamin D deficiency rickets. This condition was observed in a total of 16 (0.6%) non-adults from parish and monastic sites, notably, eight cases were reported from the single site of Wharram Percy, Malton (Mays, 2007). A slightly higher proportion of non-adults from hospitals were reported with evidence of rickets (n = 16, 1.1%). Possible reasons for the differences in the rates of pathologies and trauma recorded for the hospital and non-hospital populations will be explored in the following discussion in Chapter 6.

5.10 Summary

This chapter has detailed the osteological and archaeological data for non-adults from medieval hospital sites in England and the results of statistical analyses. The influence of the large data set from St Mary Spital, London (n = 1,070), is apparent, as it forms 71.0% of the total data analysed. When the demographics of all non-adults from hospital sites are considered (n = 1,506), younger juveniles form the lowest number of individuals (n = 307, 20.4%), followed by older juveniles (n = 504, 33.5%), and adolescents (n = 695, 46.1%) comprise the highest number of individuals. However, when the data from St Mary Spital were removed this trend is reversed, with younger juveniles (n = 167, 38.3%) constituting the higher number of non-adults, and adolescents (n = 126, 28.9%) the lowest. Despite this, the results of analyses on Group A, which includes the data for all non-adults, and Group B, which excludes the St Mary Spital, London, data, are consistent overall. Nonetheless, there are some differences in the results between these groups, particularly those relating to hospital location.

The results demonstrate that pathologies and trauma generally occurred at higher rates in adolescents, than older or younger juveniles. This is to be reasonably expected as the risks or opportunities to acquire pathologies or trauma typically increase with age. There are some exceptions to this pattern however, for example Vitamin D deficiency rickets, which occurred most frequently in younger juveniles (12/16 reported cases, 75%). Dental disease is also generally highest in adolescents (97.9% of adolescents with teeth exhibited dental disease) and this age category was more likely to have multiple dental diseases and multiple general stress indicators. The chi-square results highlight that incidents of disease were more likely to occur in individuals who exhibited at least one general stress indicator.

The distribution of non-adults in Group A with various diseases does vary between hospital locations. For example, within the populations from the different hospital locations (urban n = 1,115, marginal n = 283, and rural n = 16), overall, higher rates of individuals displaying evidence of metabolic, joint, and the various dental diseases were from urban sites. Conversely, higher proportions of non-adults reported with congenital and infectious diseases, and miscellaneous conditions were from marginal hospitals. The data relating to trauma and hospital location revealed that whilst the highest absolute number of individuals exhibiting trauma were recorded from urban sites, the highest proportion of individuals reported with trauma were from marginal sites.

Burial practices were, overall, uniform across the different hospital sites, with non-adults primarily buried in individual graves within cemetery rows. There are some notable anomalies, including burial locations outside of the main hospital cemetery and multiple burials. Coffined burials occurred predominantly at marginal sites. It is of note that no non-adults from rural hospitals were recorded as having received a coffined burial, although a comparatively small number of non-adults (n = 16) were identified at rural sites.

The following discussion chapter will consider these results and place them within the social, economic, and environmental contexts of medieval England. Comparisons with data from contemporary English parish and monastic cemetery populations will be made, and modern-day clinical studies will be employed to explore the causes and effects of disease and trauma for non-adults.

Chapter 6. Discussion

6.1 Introduction

Hospitals, categorised in this thesis as general hospitals, leprosaria, and almshouses, served multiple functions in English medieval society. These ranged from the distribution of daily alms or providing a single night's accommodation, to the education and care of abandoned children, and the long-term housing of the poor and infirm. Consequently, understanding hospitals as a single entity can be problematic. A total of 40 medieval hospital sites, where human skeletal remains were uncovered, have been excavated to date. Non-adults were recorded at 27 of these hospitals. Osteological analyses of skeletal remains recovered from these sites have reported the age at death, and pathologies or trauma these non-adults experienced during their lives. The collation of these data enabled statistical analyses to be conducted on the demographics and health conditions of non-adults from the different types of hospital institutions.

In the following discussion, the results of the analyses will be explored. Firstly, a biocultural approach is adopted to assess family, social, and environmental factors which contributed to the health status of a non-adult. Tilley's (2015) 'Bioarchaeology of Care' model is then modified to examine the care given by hospitals to non-adults. Finally, the burial practices employed by hospitals for non-adults are explored. This discussion will be contextualised through comparisons with 11 contemporary cemetery populations from English parish and monastic sites (Appendix 4). These sites were chosen as they were all large-scale cemetery excavations (>100 individuals) (Mays *et al*., 2015) and, except for a single site (Wells Cathedral, Somerset, n = 45), included a minimum of 70 non-adults.

The rate of pathologies reported for non-adults from medieval hospitals will also be compared with the findings from Roberts and Cox's study *Health and Disease in Britain* (2003). Due to some of the issues with using secondary osteology data, explained by Roberts and Cox (2003), they did not consider age at death in relation to disease, yet their study of pathology in the medieval period is one of the most broad and comprehensive to date, comprising 16,327 skeletons from 63 medieval sites. Their data includes 582 individuals recorded from five medieval hospitals.[5] For the purposes of this present thesis, where the source data used by Roberts and Cox (2003) to determine the prevalence of pathologies was stated within their publication, the hospital figures have been removed. Thus, an average rate of pathologies for individuals (adults and non-adults) in the medieval period from non-hospital sites was created, to allow a clearer comparison to be made with the non-adult hospital population considered herein.

The practices of European medieval hospitals, and modern clinical studies will be utilised to explore disease and care. Modern clinical studies cannot be used to directly infer causation of illness or disease in past populations. However, they can indicate associations that exist today, and would have been influential in the past, between social and economic status, environmental factors, physical activities, and health outcomes for individuals.

6.2 Health Risks in the Medieval Period

The initial section of this discussion focuses on the range of factors which contributed to the health status and premature deaths of non-adults during the medieval period. Interpretations centre on three aspects of a non-adult's development: the family, environmental factors, and work. As references to non-adults in historical documentation are limited, studies of modern-day populations will also be utilised to explore the impacts of family relationships, diet, poverty, pollution, and economic activities on the life experiences of non-adults during the medieval period.

6.2.1 Family and Home Environments

Infant mortality was high in the medieval period: using parish registers from the latter half of the 16th century, Orme (2001) estimated medieval neonatal mortality rates of 27%, and 12% for under five-year-olds. To contextualise this, the World Health Organisation (2006b) estimate the present mortality rate of under one-year-olds in developing countries is 5%. Maternal health, diet, the home environment, and adult supervision influenced the risks of mortality for younger juveniles (Lewis,

[5] St Bartholomew's, Bristol; St Giles, Brough; St James and St Mary Magdalene, Chichester; St Leonard's, Newark; and St Mary Spital, London.

2007; Beaumont *et al*., 2015; Gowland, 2015; Halcrow *et al*., 2017; Gowland, 2018; Craig-Atkins *et al*., 2018). These factors will be explored to gain a better understanding of the short lives of younger juveniles buried at medieval hospital sites.

6.2.1.1 Congenital Conditions

Foetal developmental defects are a risk factor in the onset of disease or early mortality. Most congenital conditions (approximately 90%) are caused by intrinsic genetic factors, although extrinsic influences can be causative agents (Reid, 2001; WHO, 2006b; Roberts and Manchester, 2010). Cases of congenital diseases were significantly higher in adolescents than younger juveniles from medieval hospital sites, although, the recognition of a congenital anomaly in younger juveniles is problematic as the skeleton is still in the early stages of developing (Lewis, 2018; Brickley *et al*., 2020). Roberts and Cox (2003) found a crude prevalence rate (CPR) of 1.9% for congenital conditions in adult and non-adult medieval skeletal remains. This is lower than the 2.6% of non-adults exhibiting congenital conditions from medieval parish and monastic cemeteries, identified in this current study (Appendix 4). Hospital sites have a marginally higher rate of 2.8%, suggesting slightly more non-adults with congenital conditions were buried in hospital locations than elsewhere.

Studies on the impact of social conditions on the development of congenital anomalies are scarce (Pawluk *et al*., 2014). Consequently, identifying risk factors which could account for the higher number of non-adults with congenital conditions at hospital sites is challenging. Although, as explored in Section 3.6.1, an association has been identified between a higher prevalence of congenital conditions in younger juveniles and poverty (Matin *et al*., 2020).

Many congenital conditions, such as spina bifida occulta or mild spondylolysis do not produce appreciable symptoms (Roberts and Cox, 2003; Roberts and Manchester, 2010; Lewis, 2018). Conversely, individuals born, for example, with limb impairments, may not have been able to participate fully within society. Adaptations, such as crutches or artificial limbs are portrayed in imagery from the medieval period, and these devices could have been used to enable an individual to engage in societal activities (Roberts, 2000b; Hernigou, 2014). Metzler (2013) considers whether non-adults with permanent disabilities or infirmities, who were otherwise healthy, may have been stigmatised by society. Although, as Gilchrist

(2012) argues, there was no single social attitude to disability or disfigurement in the medieval period: the life experiences of an individual with a congenital anomaly, would have been mitigated or aggravated by other factors such as family life and their socio-economic situation. Many adolescents who entered hospitals would, arguably, have done so because they lacked familial support (see Section 6.2.3). Thus, the absence of a support network, as opposed to the presence of a congenital condition, conceivably prompted their need for a hospital place.

6.2.1.2 Early Nutrition

For neonates, receiving adequate nutrition is vital for their development. In the current study 22 non-adults with delayed skeletal growth were identified, notably in a higher number of younger juveniles, with the majority (n = 20, 91%) from leprosaria. Modern-day studies in Ethiopia of the babies of mothers with Hansen's disease, found they have a lower birth weight, are more susceptible to infections, and experience higher rates of mortality when compared to babies of mothers who do not have Hansen's disease (Duncan *et al*., 2007; Sarkar and Pradhan, 2016). A modern-day study of women with Hansen's disease in India found that 49% did not breastfeed their children due to fears of contagion (Zodpey *et al*., 2000). During the medieval period, similar fears existed: it was believed leprosy could be transmitted through the womb and by close contact between mother and child after birth (Rawcliffe, 2006). Although wet-nursing was an established practice amongst higher status women in the medieval period (van der Lugt, 2019), their use by women with leprosy is not recorded. Alternative sustenance was available in the form of animal milk, honey-based mixtures, and pap (flour or bread in water) which could be artificially fed to a new-born with modified animal horns or pottery vessels (Hooper, 1996; Gilchrist, 2012; Craig-Atkins *et al*., 2018; van der Lugt, 2019). However, in addition to its unique balance of nutritional constituents, breastmilk also contains important immunological components which are highly advantageous to an infant (Lewis, 2007; Mays, 2010b; Craig-Atkins *et al*., 2018). Consequently, neonates who were not breastfed were at a greater risk of undernutrition, infectious morbidity, early mortality, and growth disruption (Halcrow *et al*., 2017; Craig-Atkins *et al*., 2018).

Further indicators of malnutrition or stress in childhood are cribra orbitalia and dental enamel hypoplasia (DEH). The CPR of cribra orbitalia in non-adults from hospital sites (32.3%) was higher compared to those from medieval parish and monastic sites (21.8%), whilst the proportion of non-adults with DEH from hospital settings (55.2%) was substantially greater than those from contemporary sites (12.2%). Roberts and Cox (2003) identified lower rates of both cribra orbitalia (10.5%) and DEH (37.7%) in the British medieval population, although the higher rates in a population solely comprised of non-adults, may be accounted for by a higher mortality risk for non-adults with these stress indicators (Armelagos *et al*., 2009; McFadden and Oxenham, 2020). The relationship between skeletal evidence of stress indicators and the risk of mortality is complex due to the osteological paradox (see Chapter 3) (Wood *et al*., 1992; DeWitte and Stojanowski, 2015; McFadden and Oxenham, 2020). This is potentially illustrated by the statistically significant higher incidence of cribra orbitalia and DEH in adolescents than juveniles from the hospital populations. Juveniles who experienced acute nutritional stress or disease may have died before any skeletal modifications could form (Wright and Yoder, 2003; DeWitte and Stojanowski, 2015). Conversely, the higher incidence in adolescents indicates these individuals were able to survive episodes of prolonged malnutrition and infection (Wood *et al*., 1992).

Within the hospital populations, the data from St Mary Spital elevated the average rates of both cribra orbitalia and DEH. When data from this site are removed, the occurrence of cribra orbitalia (19.4%) is slightly lower than that at contemporary cemetery sites. The CPR of DEH also falls (31.8%), although to a level which remains higher than medieval parish and monastic sites. Whilst there are multiple causes of cribra orbitalia (McFadden and Oxenham, 2020), it is typically related to a lack of iron caused by an inadequate intake of meat and fresh vegetables, whilst DEH is related to numerous factors including infection and malnutrition (Kozak and Krenz-Niedbala, 2002). These findings indicate that non-adults from hospitals outside London, experienced a similar risk in early life as their peers, of the combination of malnutrition and infectious disease, which could result in iron-deficiency anaemia and the development of cribra orbitalia (Balarajan *et al*., 2011). However, the higher rates of DEH reported for non-adults from hospital sites, suggests they were at an increased risk than their contemporaries of experiencing stressors that affected calcium homeostasis and metabolism (Kozak and Krenz-Niedbala, 2002).

The prevalence of both cribra orbitalia and DEH were found to be higher in urban general hospitals, than marginal or rural sites. Non-adults from St Mary Spital, London, exhibited a particularly high rate of DEH (61.0%). Two comparative medieval London cemetery sites, East Smithfield (35.2%) and St Mary Graces (21.1%) reported a similar or lower occurrence of DEH than the medieval population average (Bekvalac *et al*., 2007; Cowal *et al*., 2008), suggestive of the heterogeneous nature of medieval London's population. The risk of disease in urban areas was exacerbated by the density of accommodation and higher levels of pollution found in the poorest quarters of London. These districts were often located in marginal areas of the city, outside of the areas governed by the City of London ordinances (Walker, 2012b). The high level of DEH recorded in non-adults from St Mary Spital, indicates those buried within this hospital experienced prolonged periods of malnutrition or infection, and were more vulnerable to the risks associated with social and economic poverty, before entering the hospital.

6.2.1.3 Parental Practices

Both diet and parental practices influence the risks of younger juveniles developing pathologies such as Vitamin D deficiency rickets (Roberts and Manchester, 2010; Veselka, 2019; Veselka *et al*., 2021). The active skeletal changes of rickets occur most frequently in infants between the ages of eight and 24 months (Snoddy *et al*., 2016). This is reflected in the findings from the medieval hospital data, as a statistically significant higher number of younger juveniles were reported with the disease, although this may be influenced by osteological methods used in the earlier reports considered in this current research, before the identification of residual rickets was possible. Evidence of rickets is rare in the medieval period: Roberts and Cox (2003) found a crude prevalence rate during this period of 0.7%, slightly lower than the occurrence of 1.1% in non-adults from hospital sites. Diet and weaning practices are contributory factors to rickets (Brickley *et al*., 2020). Yet most vitamin D is acquired by humans through exposure to sunlight and is therefore influenced by parental practices and childhood behaviour (Mays, 2010b; Veselka *et al*., 2021).

Swaddling of babies and keeping them in semi-dark environments was practised during the medieval period in the belief it would help infants limbs to grow straight and strong, and keep them safe from accidental injury (Orme, 2001; Gilchrist, 2012). A total of 16 (0.6%) non-adults were reported from non-hospital sites with Vitamin D deficiency rickets. This includes eight (2.4%) infants with active rickets at the rural site of Wharram Percy, Malton (North Yorkshire), an unusually high number of individuals from a single site (Mays, 2007). Ortner and Mays (1998: 54) suggest that these individuals could have been “sickly” and therefore kept indoors. This reasoning may also be applicable to the younger juveniles from hospital sites who developed rickets. Eight (50%) of the non-adults with rickets displayed evidence of additional pathologies including delayed growth, cribra orbitalia, and DEH, and two exhibited fractures. These are indicators of stressors which possibly caused general ill-health and resulted in these individuals being sheltered, inside, away from any external dangers, but also away from sunlight. Most non-adults from hospital sites, however, did not develop rickets, suggesting that they were exposed to sufficient levels of sunlight or were fed high quantities of food containing vitamin D.

Parental practices also influence the risks of younger juveniles having accidents or experiencing trauma. The small number (n = 3, 1%) of younger juveniles from hospital sites reported with trauma may be related to the rapid healing of fractures in this age group, evidence for which can be obliterated by the normal growth and development of the bone (Ortner, 2003; Verlinden and Lewis, 2015). All three individuals had sustained an injury to the mandible: two were reported to have broken teeth and one exhibited a fractured mandible. The young juvenile with a mandible hairline fracture also had rickets, which is associated with inadequate bone mineralisation and low bone density (Mays *et al*., 2006; Judd, 2008). Consequently, Judd (2008) suggests rickets potentially increased the risk of this individual sustaining a fracture. In a clinical study focusing on infants with rickets, Chapman *et al*. (2010) found the greatest fracture risk was for infants who were mobile and engaged in typical childhood activities. In their study, the most common fracture location were the long bones, and no fractures to the skull were reported (Chapman *et al*., 2010). Trauma to the mandible is rare in under five-year-olds today and has been associated with child abuse (Glazer *et al*., 2011), although the non-adult from the hospital site exhibited no other indicators suggestive of abuse. Mandibular fractures are frequently the result of accidental falls (*ibid*.), and this was likely to be the case in the past too. However, the low numbers of trauma reported in younger juveniles from hospital sites indicates that the majority of infants and children were supervised and kept away from hazards, or that if injuries did occur, they healed, leaving no visible trace on the skeletal remains.

As children grow older, their diets change and become more akin to that of adults, promoting dental disease. Typically, older juveniles and adolescents spend increasingly more time outside of the family home, encountering a greater number of people and becoming exposed to new environments (Orme, 2001). These elements further influence the health and development of non-adults and are the subject of the next section in this discussion.

6.2.2 Urban and Rural Environments

Most of the hospitals built during the medieval period were associated with urban centres to cater for the needs of an increasing urban population (Orme and Webster, 1995). Reflecting this, the majority (n = 21, 78%) of the 27 hospitals considered in this thesis were built in locations related to towns, whilst six (22%) were rural institutions. Approximately 90% of the English population lived in rural areas, hence, many of the non-adults who entered urban hospitals were migrants, although others originated from or resided in towns prior to entering a hospital (Gilchrist, 1995; Galloway, 2005; Robb *et al.*, 2021).

6.2.2.1 Diet and Dental Disease

Dental diseases (caries, DEH, periodontal disease, calculus, abscesses) or dental anomalies, were identified in most non-adults from hospital sites (n = 871/964, 90%). Medieval medical texts promoted the use of rubbing teeth with herbal powders and removing food debris after eating to prevent teeth rotting (Anderson, 2004), although only the wealthier of society could afford physicians' fees and benefit from this advice (*ibid*.). Consequently, poor levels of oral hygiene were common in the medieval period. Hence, Roberts and Manchester (2010) argue, most population differences observed in dental diseases, reflect the effects of dietary components and infections, rather than oral hygiene practices.

The prevalence of all the dental diseases analysed in this current study, were higher in adolescents than juveniles. This is as expected, as dental diseases have more opportunity to develop throughout an individual's life (Redfern, 2012a). Caries were the only exception to this pattern of age related dental disease, and were statistically more prevalent in older juveniles than adolescents. This may relate to the emergence of permanent dentition between the ages of six and 12 years (Scheuer and Black, 2004). Changes in diet during juvenescence further contribute to dental disease. Mahoney's (2016) study of microwear on deciduous tooth enamel demonstrates that in the medieval period, abrasive foods were consumed by younger juveniles from four years of age, whilst from the age of six years, diets became increasing harder and more akin to an adult's diet. In a clinical study, Clarke *et al*. (2006) found younger juveniles who were malnourished, and had an inadequate intake of iron, experienced higher level of caries than their well-nourished counterparts. Caries are infectious and therefore would spread from deciduous to permanent teeth. One potential explanation for the higher incidence of caries observed in older juveniles from medieval hospital sites, is that due to having mixed deciduous and permanent teeth, they may have exhibited more caries than adolescents, who would have lost any carious deciduous teeth.

Most older juveniles (235/341, 69%) and adolescents (431/527, 82%) exhibited two or more dental diseases. Dental diseases are interrelated: for example, the malalignment or crowding of teeth can exacerbate the build-up of calculus and has been associated with higher incidences of caries and periodontal disease (Peretz and Machtei, 1996; Shrestha *et al*., 2015). Similarly, caries can predispose an individual to abscesses if the pulp cavity becomes exposed to bacterial infection, and the accumulation of calculus is related to an increase in the development of periodontal disease (Roberts and Manchester, 2010).

Apart from calculus, rates of caries, periodontal disease, and abscesses were lower in the hospital non-adult populations, than the medieval averages established by Roberts and Cox (2003). Although, as aforementioned, the extent of dental diseases increases with age, and therefore will be higher in an entire population of adults and children, than one comprised solely of non-adults (Power, 1985/86; DeWitte, 2010b). However, when comparing adult populations, Caffell (2004) found that adults from medieval hospital cemeteries exhibited a higher rate of caries than those from parish or monastic cemeteries. Similarly, when non-adults are compared, those from hospital sites had a higher frequency of caries (33%) than non-adults from contemporary parish and monastic cemeteries (8.1%) (Section 5.9). Yet, as with cribra orbitalia and DEH, the rates of dental disease in the non-adult hospital population were inflated by the single site of St Mary Spital, London. When the data from this site were removed, the prevalence of dental disease becomes closer to that observed in comparative non-adult populations. Thus, non-adults from hospitals outside of London, were likely to have consumed a diet comparable to their peers.

Non-adults buried within the London hospital of St Mary Spital, thus experienced higher rates of dental disease than their contemporaries in other hospitals and the wider community. Rates of caries, calculus, periodontitis, and abscesses were also higher in the St Mary Spital non-adult population than in those from two contemporary London cemeteries, East Smithfield (Cowal *et al*., 2008), and St Mary

Graces (Bekvalac *et al*., 2007). The population from St Mary Spital consisted of a higher proportion of adolescents than juveniles, and this demographic may have influenced the rates of dental disease observed at this particular site (DeWitte, 2010a). It is not known how many of the non-adults from St Mary Spital grew up in urban London or migrated from rural areas, and understanding the dietary causes of dental disease are complex: foods such as coarse bread are associated with the poor, whilst conversely, diets which included sugar are associated with wealth, yet both diets can cause dental disease. However, the overall dental health of non-adults buried at St Mary Spital suggests they consumed diets associated with the poorest sectors of society and probably experienced prolonged episodes of under-nutrition which, when combined with a lack of oral hygiene, left them more susceptible to dental disease (Redfern, 2012a).

All dental diseases recorded in the hospital populations were found to be greater in non-adults from urban hospitals than marginal sites. Griffin (2017) argues that rural populations produced their own food and consumed more meat, resulting in a better diet and less dental disease. Conversely, urban residents who relied primarily on buying food in markets, may have consumed a cheaper grain-based diet, increasing the occurrence of dental disease (Griffin, 2017). Zooarchaeological evidence, however, indicates that more meat was consumed in urban centres (Albarella, 2005). Albarella (2005) argues though, that differences in meat consumption patterns reflects the diet of wealthier urban residents, with poorer people in towns consuming a predominantly vegetarian diet. Thus, differences in diet may relate to both the environment in which people lived and their socio-economic status (Albarella, 2005; Müldner and Richards, 2005). The diets provided by hospitals to inmates is discussed below (Section 6.3), although as oral health is related to diet, the data from this current study indicates that the potentially longer-term inmates of leprosaria consumed a better-quality diet than those who accessed typically short-term care from general hospitals.

6.2.2.2 Risk of Disease

Skeletal changes indicative of an infectious disease were identified in 283 (20%) non-adults from hospital sites. Multiple factors increase an individual's susceptibility to disease including poor diets, which can depress the immune system (Roberts and Manchester, 2010). Other extrinsic aspects of urban and rural environments influenced the development of disease: inadequate housing conditions, high population density, pollution, and poor sanitation measures, created favourable environments for bacteria, viruses, fungi, and parasites, and promoted the transmission of communicable diseases (Manchester, 1992; Roberts, 2000a; Rawcliffe, 2013; King and Henderson, 2014; Robb *et al*, 2021). Hence, infectious diseases were a significant cause of death during the medieval period (Robb *et al*., 2021). As previously mentioned in Chapter 3 of this thesis, many infections only effect the body's soft tissues, leaving no evidential trace on skeletal remains (Roberts, 2000a). Therefore, given the burden of disease in medieval environments, it is probable that many more non-adults buried in medieval hospitals died from infectious diseases than can be osteologically identified (Roberts and Manchester, 2010; Robb *et al.*, 2021).

Skeletal evidence for infectious disease and subperiosteal new bone formation (indicative of a non-specific infection), were observed in a statistically significant greater proportion of adolescents than juveniles from hospital sites. Grauer (1993) found that incident rates of subperiosteal new bone formation in skeletal populations increase with age, indicating survival from chronic infection. Infants and younger juveniles are vulnerable to acute infections, especially during the weaning period when access to the nutrients and immunity provided by breastmilk is reduced (Hühne-Osterloh and Grupe, 1989; Katzenberg *et al*., 1996; Mays, 2010b). In the present day, pneumonia, diarrhoea, and malaria are leading causes of death in children under five years of age (WHO, 2020) and would have caused deaths in this age group during the medieval period (Redfern, 2012a; Stone, 2013). However, these infections are rarely observable in the archaeological record (Roberts and Manchester, 2010). Furthermore, subperiosteal new bone formation in younger juveniles can be mistaken for new bone developing as part of normal growth, making the identification problematic in younger age groups (Roberts, 2000a; Lewis, 2008; Dawson-Hobbis, 2017).

The CPR of subperiosteal new bone formation (13.9%) for non-adults from hospital sites is comparable with that for the general medieval population (13.8%) established by Roberts and Cox (2003). The CPR from contemporary non-hospital sites utilised in this current study, is lower at 10.7%. Non-adults buried in hospital sites were therefore exposed to a similar risk of developing subperiosteal new bone formation as the adult population, and at a greater risk than contemporary non-adults. Subperiosteal new bone formation is a result of the same pathological changes in bone tissue, in response to multiple causative agents (Weston, 2008).

However, Roberts and Cox (2003: 235) argue that subperiosteal new bone formation is "a reflection of living conditions". Thus, prevalence rates are arguably associated with social status, with higher status individuals at a lower risk of exposure to chronic infections (Lewis, 2002b; Bennike *et al*., 2005). Contrary to this, in a study of three medieval cemetery populations, Dawson-Hobbis (2017) identified higher rates of stress indicators, including subperiosteal new bone formation, from higher status non-adults. It is possible that the more advantaged in society were better able to survive episodes of stress, and therefore are potentially more likely to exhibit stress indicators than those of lower economic and health status (Dawson-Hobbis, 2017). Consequently, the relationship between subperiosteal new bone formation and social status is uncertain. However, as adolescents from hospital sites were at a similar risk of developing subperiosteal new bone formation as adults, it is likely they entered occupations or environments, more akin to those of adults, at an earlier age than was the medieval norm.

Rates for infectious disease were significantly higher at hospitals in marginal locations as opposed to urban or rural sites. This may relate to the function of most marginal hospitals as leprosaria or almshouses, which provided long-term housing for inmates in poverty with chronic conditions (Gilchrist, 1995; Rawcliffe, 2006). Although there is sparse documentary evidence relating to non-adults and leprosaria, it is likely that some children entered with leprous parents to prevent them effectively becoming orphaned, whilst others had leprosy themselves (Bennike *et al*., 2005). Conversely, urban general hospitals provided relief from poverty and illness with short-term accommodation and alms (Gilchrist, 1995; Rawcliffe, 1999). Towns are associated with housing conditions and pollution which could increase the risk of disease (Schofield and Vince, 2003). However, the environment of marginal areas could also be unhealthy. They could be marshy and prone to flooding, and were the location of many polluting trades, for example charcoal production, tanning, iron smelting, and lime burning (Schofield and Vince, 2003; Rawcliffe, 2005, 2006; Connell *et al*., 2012).

Subperiosteal new bone formation on the lower limbs was proportionately higher in non-adults from marginal than urban hospitals. Subperiosteal new bone formation on the tibiae and fibulae are frequently observed on skeletal remains of leprous individuals and can manifest in the early stages of leprosy (Lewis *et al*., 1995b; Schultz and Roberts, 2002). Of the 29 non-adults from marginal sites with subperiosteal new bone formation on the lower leg bones, 11 (38%) exhibited indicators of leprosy. However, due its proximity to the skin surface, the tibiae are the most common skeletal element to develop subperiosteal new bone formation, which can form as a secondary response to minor trauma, skin lesions, and bacterial infections (Roberts, 2000a; Ortner, 2003; Roberts and Manchester, 2010). Thus, whilst leprosy is associated with subperiosteal new bone formation on the tibia, trauma or infections which occurred independently of leprosy, also need to be considered as possible causative agents.

The number of cases of sinusitis (n = 18) were too small to permit statistical analysis, although it was identified in non-adults from urban, marginal, and rural hospitals. Sinusitis is often associated with poor air quality in urban centres. However as reviewed in Section 3.6.2, poor housing conditions and domestic industries, in addition to more intensive polluting industries, could be found in both urban and rural locations in the medieval period, contributing to sinusitis and other respiratory infections.

Rates of tuberculosis (TB) in past populations are under-estimated as skeletal changes occur in approximately 5-7% of people with the condition (Roberts, 2000a; Roberts and Cox, 2003; Mays, 2010a). Therefore, more non-adults from medieval hospital sites were likely to have contracted TB than the 33 (2.2%) cases reported. This rate is, however, higher than the medieval average of 0.8% established by Roberts and Cox (2003). A further 40 non-adults from hospital sites exhibited subperiosteal new bone formation on their ribs, which Roberts *et al*. (1998) argue, should be recognised as a diagnostic indicator of TB. Studies, including those on historical skeletal collections, suggest that whilst other diseases may cause these rib lesions, TB is the most probable cause (Roberts *et al*., 1998; Roberts, 2000a; Santos and Roberts, 2006). However, Mays *et al*. (2002) analysed aDNA from seven individuals from the medieval site of Wharram Percy, who exhibited subperiosteal new bone formation on the ribs. No association between rib lesions and TB was identified, shedding doubt on the presumption of a TB diagnosis based on the presence of subperiosteal new bone formation.

The presence of TB in non-adults from hospital sites was significantly higher in adolescents than younger juveniles. Dawson and Robson Brown (2012) suggest TB is more difficult to diagnose on young children due to the cartilaginous, as opposed to bony, nature of the skeleton. Furthermore, in a review analysing the occurrence of TB during the 20th century, the mortality rate of 0-4-year-olds with TB in the pre-treatment era (prior to A.D. 1946), was 44%, compared to 15% of 5-14-year-olds

(Jenkins *et al*., 2017). Thus, younger juveniles may have contracted TB at a similar rate to adolescents in the medieval period but died before the condition manifested skeletally. Alternatively, the higher rates in adolescents may reflect changes in activities and living conditions during this life stage, as they migrated to new areas or became involved in different work activities (Redfern, 2012b).

As discussed in Section 3.6.2, conditions existed in both urban and rural environments which would have increased the risk of a non-adult contracting TB. However, contributary factors such as a higher population density, poor sanitary conditions, and poverty were often intensified in urban centres. Thus, for adolescents who lived in or migrated to towns, the risks of contracting TB from people already infected with the disease, would have increased, and possibly resulted in the need of a hospital's assistance. The influences of migration and work on non-adult health is the focus of the next section of this discussion.

6.2.3 Migration and Work

In the current study, a significantly greater number of adolescents were identified from urban than marginal hospitals. Urban hospitals including St John, Lichfield (Goacher *et al*., 2016), St Mary Spital, London (Connell *et al*., 2012), and St John, Cambridge (Dodwell, 2012), reported unexpectedly high numbers of adolescents. Typically, adolescents form a low proportion of an attritional cemetery population (Margerison and Knüsel, 2002; Chamberlain, 2006), as an individual's immune system is well developed by this age, reducing their risk of mortality (Simon *et al*., 2015). The only comparative cemetery site with a high number of adolescents was the Black Death cemetery at East Smithfield, London (Cowal *et al*. 2008) (Appendix 5). However, this may be related to a specific mortality profile of plague cemeteries. In a demographic study of plague cemeteries across Europe, Kacki (2021) consistently identified higher numbers of older juveniles and adolescents than younger juveniles. Redfern (2012a) suggests adolescents migrating to urban areas for work may explain the demography at St Mary Spital, London. When the St Mary Spital, data were removed from analyses, adolescents accounted for the lowest proportion of non-adults from hospital sites, thus indicating, that London and potentially other urban areas were attractive, but also risky destinations for adolescents (Orme, 2001). A statistically significant decline in the number of older juveniles and adolescents buried at St Mary Spital, was identified in the final phase of the hospital's existence (A.D. 1400-1539). This may relate to changes in working regulations following the famines and plagues of the 14th century, which compelled many non-adults to remain in rural agricultural employment (see Chapter 2). Hence, fewer non-adults were likely to be migrating to urban areas and the need for hospital charity by this age group may have diminished.

Urban centres offered opportunities for adolescents seeking work, for example urban households had twice as many servants as those in rural areas (Kowaleski, 2014) and town guilds offered a pathway to citizenship through apprenticeships (Spindler, 2011). As Lewis (2016) states, however, secured apprenticeships were typically arranged by wealthier families, whilst those from poorer families migrated to seek more menial and less secure positions. Children could enter the workplace and domestic service from six or seven years of age (Hanawalt, 1993; Lewis, 2016). Yet, older and stronger children would have been more useful within a workplace and apprenticeships were typically offered to adolescents who were the principal non-adult age group seeking employment (Hanawalt, 1993; Orme, 2001; Lewis, 2016).

6.2.3.1 Pilgrimage

Hospitals catering for pilgrims were also found to have a higher proportion of adolescents than juveniles. Little has been written on the participation of non-adults in pilgrimages. Miracle stories testify that children accompanied their parents on pilgrimage to give thanks or to seek a cure for an illness or disability (Gordon, 1991; Sumption, 2003). Medieval chroniclers recorded events of mass pilgrimages, undertaken by hundreds of children in France and Germany (Sumption, 1975). They state that the children, aged 11 to 15 years old, were from the poorest families, and left home without their parents' knowledge: the chroniclers debate whether true devotion or poverty inspired children to pilgrimage, during which they would receive the charity afforded to pilgrims, but denied to beggars (Sumption, 1975). No similar accounts are documented for England, although these chronicles demonstrate that adolescents did undertake pilgrimages independently. Adolescents may have conducted pilgrimage for their own sake, however, pilgrimage by proxy was an effective means of pilgrimage through the medieval period (Craig, 2009). Adolescents or young adults working in service could be paid by their employer or hired by a sponsor to undertake a pilgrimage on their behalf (Webb, 2000; Craig, 2009). Medieval wills further testify to the importance of pilgrimage by proxy. Fort (2018) cites examples of fathers requesting their sons to undertake pilgrimage on their behalf, and of others directing payments to send someone on a pilgrimage in their name, to ensure a good death. The ages of those acting as proxy were not given, although it is plausible adolescents assumed these roles. Thus, adolescents following pilgrim routes potentially used hospitals and benefitted from their hospitality.

6.2.3.2 Work and Disease

Except for a single younger juvenile and five older juveniles, joint diseases were predominantly reported in adolescents from hospital sites. Joint disease is typically associated with old age, although as these individuals died prior to 18 years of age, load bearing activities or trauma are probable causes (Mays, 2010a; Roberts and Manchester, 2010). Notably, a higher number of non-adults, with a wider range of joint diseases, were reported from hospital sites (n = 124, 8.2%) than comparable parish or monastic cemetery sites (n = 12, 0.5%). Schmorl's nodes (SN) were the predominant joint disease reported in non-adults from hospital sites, with all but eight cases from St Mary Spital, London. This may be due to differences in osteological observations and recording methods or may indicate that adolescents from hospital sites, particularly St Mary Spital, were engaged in tasks which placed a greater strain on their spines and joints than their contemporaries.

The location of SNs within the vertebra can influence the degree of pain an individual experiences (Faccia and Williams, 2008). If adolescents had migrated some distance from their family, the pain experienced due to SNs could have left them unable to work and in need of hospital charitable support (see Section 3.6.3). Such a scenario may account for the preponderance of non-adults reported with SNs from the hospital of St Mary Spital, London.

Further corroboration of adolescents experiencing joint stress was evidenced by the occurrence of osteochondritis dissecans (OCD). Whereas SNs indicate strain specifically to the spine, the presence of OCD illustrates episodes of repetitive micro-trauma to other distinct areas of the body (Stirland, 1996). Within the hospital non-adult population, OCD was reported on the tibiae, humeri, the spine, and the foot. Many modern-day studies identify the increasing impact of competitive elite sport as a primary cause of OCD in non-adults (Robertson *et al*., 2003; Kocher *et al*., 2006; Churchill *et al*., 2016; Accadbled *et al*., 2018). Whilst modern-day sporting activities cannot be directly paralleled with activity in the medieval period, these studies demonstrate the high intensity level of activity required to produce OCD.

Within this current study, only three non-adults exhibiting OCD were assigned a sex through osteological analyses, all of which were male. OCD was identified on the knee and ankle of one individual, the spine of another (Tucker, n.d.) and the knee of the third non-adult (Magilton *et al*., 2008). However previous studies of OCD in past populations have illustrated that both males and females experienced the condition, although often in particular skeletal locations (see Section 3.6.3) indicative of a divergence of labour (Lewis, 2016; Vikatou *et al*., 2017). Although the data from this current study are too small to draw conclusions regarding sex and working roles, both male and female adolescents were engaged in occupations during the medieval period which resulted in a range of injuries and skeletal micro-trauma, to different areas of the body.

6.2.3.3 Migration, Work, and Trauma

Fractures were observed in significantly higher rates of adolescents than juveniles from hospital sites (24/32, 75%). Gordon (1991) states that medieval miracle stories imply that adolescents were the age group at the lowest risk of sustaining trauma. In these stories, parents ask for intercessory help for their children, and only 11 of the 134 (8%) cases cited, related to adolescents (Gordon, 1991). The low incidence of recorded adolescent injuries may therefore be due to the familial independence of many in this age category. Certain injuries are associated with different age groups: fractures to the clavicle are common in infants, whilst fractures to the forearm increase with age, as adolescents pursue a wider range of activities and fracture patterns become more akin to those in adults (Jones, 1994). Yet, unless a fracture occurred peri-mortem, it is difficult to ascertain at what age a healed fracture occurred (Grauer and Roberts, 1996; Roberts and Manchester, 2010). Indeed, Redfern (2012a) has suggested that the location pattern of some fractures identified on adolescents from St Mary Spital, London, suggests they were sustained earlier in life. Consequently, some of the fractures identified in this current study in adolescents, may have occurred during juvenescence.

The rate of non-adult fractures from hospital sites (36/1,414, 2.5%) are higher than the rate from contemporary parish and monastic sites (17/2,618, 0.6%). In a study on adolescents in medieval England, Lewis (2016) found a fracture rate of 4.6% in rural populations and 6.4% in urban groups, over twice the rate observed in non-adults from hospital sites, although Lewis' (2016) study included individuals aged 6.6-25 years, and a peak in trauma was observed in 17-25-year-olds. The extension of the adolescent age range, beyond that of this current study, is therefore a likely reason for the higher incidence of fractures. Thus, non-adults from hospital sites appear to have been at an increased risk of sustaining fractures than their peers.

Whilst sex could not be established for most non-adults in this current study, four adolescents exhibiting fractures, were recorded as male (Tucker, n.d.; Magilton *et al*. 2008; Connell *et al*., 2012). Analysis by Connell *et al*. (2012) of the adult skeletal remains from St Mary Spital, London, identified more healed fractures in males than females. Walker (2012b) states that many of the injuries were possibly sustained during adolescence, with boys having an increased risk of trauma from 12 years of age. This accords with modern-day studies in which boys are identified as being at a greater risk of fracture than girls (Cooper *et al*., 2009; Hedström *et al*., 2010; Kaewpornsawan *et al*., 2014). The risk of fracture increases for males during adolescence due to changes in activity behaviour, with male adolescents typically undertaking higher intensity activities and engaging in high-risk-activity (Glencross and Stuart-Macadam, 2000; Goulding, 2007). Yet, adolescence is also a time of rapid skeletal growth and elevated bone turnover, resulting in a lower bone mineral density, which can also result in this age group being more vulnerable to fractures (Goulding, 2007; Cooper *et al*., 2009).

Possibly due the different activities undertaken by non-adults in the medieval period, or the small number of fractures reported in non-adults from medieval hospitals, the fracture locations identified in this current study differ to the dominance of arm and hand fractures seen in modern clinical studies (Hedström *et al*., 2010; Kaewpornsawan *et al*., 2014). Fracture locations identified within the hospital non-adult population were more evenly distributed across the skeletal elements of the upper (n = 5) and lower long bones (n = 5), the hands (n = 4) and feet (n = 5), and the spine (n = 4) and ribs (n = 6).

The range of fracture types (including compression, depressed, transverse, greenstick, oblique, stress, and impaction fractures) sustained by non-adults, further indicates that a variety of mechanisms were involved in these episodes of trauma. These mechanisms include direct blows, indirect or rotational forces, compressive, and high energy crushing forces (Mays, 2010a; Roberts and Manchester, 2010; Dittmar *et al*., 2021). Fractures to the head, hands, upper limbs and torso were identified in the hospital non-adult population. As aforementioned, most of the individuals included in this current study were too young to have their biological sex estimated, however, Dittmar *et al*. (2021) suggest these fracture sites in females are indicative of domestic assault. Medieval accounts of female servants being beaten by their employers, demonstrate adolescents in service were subject to physical abuse (Hanawalt, 1993; Lewis, 2016). Redfern (2012a) interpreted the multiple fractures to the ribs and nasal bones sustained by an adolescent from St Mary Spital, London, as indicative of inter-personal violence. Rib fractures are considered an indicator of inter-personal violence, as a considerable compressive force is needed to cause such trauma in a non-adult (Redfern, 2012a). Gilchrist (2012: 56) has described a "culture of violence" associated with male youths in medieval urban areas. Taverns were a temptation to adolescents, where they would learn gambling, rowdy games, and other "bad habits of adult men" (Hanawalt, 1993: 116). Competitive social activities such as these could cause tensions, resulting in brawling and assaults (Hanawalt, 1993; Lewis, 2016). Krakowka (2017: 501) suggests that inter-personal violence and "alcohol-induced brawls", were more prevalent in medieval London, especially in poorer quarters, than in other parts of England. Further incidents of inter-personal violence are apparent from historical documents recording disorder and riots in London by apprentices and servants, during which deaths occurred (Hanawalt, 1993; Spindler, 2011).

In accordance with Dittmar *et al*.'s (2021) assertion that a person's socio-economic status influences their risk of sustaining trauma, the findings of this current study suggest that non-adults from medieval hospitals were from lower socio-economic communities which placed them at an increased risk of trauma and joint disease, than their peers, in both urban and rural environments. Non-adults from hospital sites were likely to have engaged in occupational activities (see Section 3.6.3), resulting in repetitive joint strain and increased risks of trauma, and conceivably, sustained injuries from inter-personal violence.

One further alternative cause of fractures which needs consideration is the co-occurrence of other pathologies. For example, an individual from the hospital of St Mary Magdalene, Winchester, exhibited rib fractures and indicators of TB and leprosy (Tucker, n.d.). Tucker (n.d.) hypothesised that severe coughing due to TB could have caused the rib fracture. The domestic and wider environmental circumstances in which a non-adult grew up, would have impacted their health status in a multitude of ways. Therefore, the co-occurrence or co-morbidity of pathologies is examined in the following section of this discussion.

6.2.4 Co-occurrence of Pathologies

6.2.4.1 Co-occurrence of General Stress Indicators and Pathologies

Within this current study, non-adults with one general stress indicator (cribra orbitalia, dental enamel hypoplasia (DEH), or subperiosteal new bone formation) were found to be statistically significantly more likely to have a second stress indicator. Cribra orbitalia and DEH are termed general stress indicators due to their multiple causal factors, however, studies into any correlation between them are limited and have produced mixed results (see Kozak and Krenz-Niedbala, 2002; Obertová and Thurzo, 2008). However, Brickley *et al*. (2020) state that there are links between metabolic disease and infectious disease, which are exacerbated by poor socio-economic status and underlying malnutrition. This is illustrated within the non-adult hospital data in the overall health of non-adults reported with Vitamin C deficiency scurvy. Although there were insufficient data on scurvy to permit statistical analysis, it is notable that 13 of the 15 (87%) non-adults reported with scurvy had additional pathological indicators, including delayed skeletal growth, cribra orbitalia, and DEH. As Steinbock (1976) states, malnutrition typically involves a deficiency of multiple nutrients to varying degrees. The hospital data suggests that due to socio-cultural factors these non-adults experienced prolonged or repetitive episodes of malnutrition or environmental stress (Brickley *et al*., 2020). If scurvy is left untreated, individuals become more prone to infection (Stirland, 2000), which potentially contributed to the premature deaths of these non-adults.

Statistically significant associations were identified in the non-adult hospital population, between those reported with multiple stress indicators and TB, Schmorl's nodes, endocranial lesions, and certain dental diseases. As discussed in Section 3.6.4, modern-day clinical studies are enhancing our understanding of the role of malnutrition and environmental stressors as both a causative factor and an accelerator of conditions such as TB (Zachariah, *et al.*, 2002; Podewils *et al*., 2011; Téllez-Navarrete *et al*., 2021). The relationships between infections and malnutrition can become bi-directional as certain infections can intensify nutritional depletion (Macallan, 1999). Hence, non-adults in the medieval period who experienced malnutrition or disease may have been at a greater risk of acquiring multiple pathologies and their health diminishing.

Rates of Schmorl's nodes (SNs) in non-adults from hospital sites, were statistically significantly higher in those who exhibited DEH and subperiosteal new bone formation. There are currently no available bioarchaeological or clinical studies which assess the relationship between these specific factors. It is possible however, that their co-occurrence in non-adults was due to lifestyle factors and socio-economic status rather than any direct inter-relationship between these pathologies. Studies on the prevalence of SNs in Italian prehistoric hierarchical societies (Robb *et al*., 2001), medieval Spanish communities (Jiménez-Brobeil *et al*., 2012), and modern-day clinical observations in the USA (Faccia and Williams, 2008) have identified higher rates of SNs in those with a lower socio-economic status. These individuals were more likely to have experienced poverty and engaged in physically demanding labour roles (Robb *et al*., 2001; Jiménez-Brobeil *et al*., 2012). If these findings can be applied to the English medieval population too, then low socio-economic status could explain the co-occurrence of SNs and general stress indicators. The diet of the poor was often limited, and they were the most at-risk population group during times of food scarcity and famine (Rubin, 1987; DeWitte and Bekvalac, 2010; Gilchrist, 2012; Slavin, 2014). This, combined with demanding physical labour, could result in non-adults being vulnerable to, and exhibiting skeletal evidence of, both malnutrition (observed through general stress indicators) and specific joint diseases.

Within the hospital non-adult population, caries, periodontal disease, calculus, and dental anomalies increased in prevalence in non-adults exhibiting stress indicators. The occurrence of general stress indicators and dental disease together, may be cyclical in nature. For example, episodes of malnutrition in younger juveniles can cause cribra orbitalia, DEH, and increase an individual's susceptibility to dental disease (Johansson *et al*., 1992; Vieira *et al*., 2020). Vieira *et al.* (2020) state nutritional deficiencies affect dentition through three mechanisms: causing defects in tooth formation, delaying the eruption of teeth, and causing alterations to the salivary glands. Micronutrients in saliva are important in maintaining a healthy oral environment, hence, a reduction in salivation increases an individual's susceptibility to developing caries (Stookey, 2008). Preterm children and children with a low birth weight who developed DEH, were identified as being at a higher risk of developing caries during juvenescence: bacteria can adhere to defective enamel more readily, and as defective enamel has a higher acid solubility it is susceptible to decay (Pascoe and Seow, 1994; Lai *et al*., 1997; Hong *et al*., 2009). Periodontal disease has also been found to evolve more rapidly in individuals who are undernourished (Sheetal *et al*., 2013). Conversely, dental disease may be a causal factor of malnutrition: modern-day studies have found that caries increase the risk of bacterial infections and it has been hypothesised that pain caused by caries can alter eating habits, resulting in iron deficiency anaemia (Shaoul *et al*., 2012; Schroth *et al*., 2013; Sheetal *et al*., 2013).

6.2.4.2 Co-occurrence of Trauma, Pathologies, and General Stress Indicators

The small number of non-adults exhibiting both trauma and any specific pathology invalidated statistical analyses. A statistically significant association was, however, identified between the presence of trauma and Schmorl's nodes (see Section 6.2.3), and incidence rates of trauma were higher in non-adults with certain infectious diseases. Therefore, generalised comments are made here, and any true association between trauma and disease is discussed with caution.

Vitamin D deficiency rickets is often associated with an increased risk of bone fracture (Paterson, 2015). Yet only two of the 16 (13%) non-adults from hospital sites with rickets also exhibited trauma. This could be due to the small sample size, although rapid bone modelling and re-modelling in young children makes fractures difficult to detect (Ortner, 2003). Furthermore, recent advances in bioarchaeology have improved the identification of rickets and scurvy in non-adults which previously, was potentially misidentified as poor preservation (Lewis, 2010). Of the 33 non-adults reported with trauma and cribra orbitalia, the most frequently occurring combination was OCD and cribra orbitalia (n = 13, 41%), followed by fracture and cribra orbitalia (n = 11, 31%). Clinical research shows that iron deficiency negatively affects bone mass density (BMD), mineral content, and bone strength (Toxqui and Vaquero, 2015; Pradita *et al*., 2020). Low BMD and bone fragility are known to increase the risk of fracture and bone trauma (Bishop *et al*., 2014). It is therefore likely that non-adults from hospital sites who experienced episodes of malnutrition as younger juveniles, were at a greater risk of sustaining bone trauma during subsequent years.

Only 25 non-adults from hospital sites exhibited indicators of both trauma and infection. In many instances, these conditions appear to be independent of each other. For example, one non-adult from St Mary Spital, London, exhibited osteitis on the right tibial diaphysis, and an unhealed rib fracture (Centre for Human Bioarchaeology, 2013). In modern clinical studies, the risk of infection following an open fracture can be as high as 30% (Dunkel *et al*., 2013). It is probable that in the pre-antibiotic era, infection levels were higher than this. Two non-adults from St Mary Spital were recorded with a healed fracture and osteomyelitis, which may have been related: one individual had a fracture to the left tibia and osteomyelitis to the left fibula, whilst the other exhibited the same conditions to the left humerus (Centre for Human Bioarchaeology, 2013). Osteomyelitis can be caused by inoculation from a penetrating trauma (Thakolkaran and Shetty, 2019), hence, the proximity of the infection sites to the fractures, suggests the fracture caused a secondary bone infection, which may explain why these individuals were in a hospital. A total of five non-adults with leprosy exhibited fractures or OCD. Leprosy can cause bone mass loss in the early stages of infection, resulting in an increased risk of bone trauma (Ribeiro *et al*., 2007). Additionally, the loss of sensory perception and visual impairments caused by leprosy, increase an individual's risk of fracture due to accidental falls (Judd and Roberts, 1998). Consequently, there appears to be a bidirectional relationship between trauma and infection: some non-adults developed infections which were potentially a causative factor of trauma, or alternatively, a result of sustaining trauma.

A statistical significance was identified between the presence of trauma and dental disease in non-adults displaying calculus. This finding may be influenced by the high percentage of non-adults who exhibited calculus (82.7%). Although, as described in Section 3.6.4, clinical and archaeological studies suggest a potential relationship between the presence of calculus and numerous medical conditions suggesting an underlying frailty (Söder *et al*., 2016; Julkunen *et al*., 2018; Yaussy and DeWitte, 2019). Whilst an association between calculus and certain diseases cannot demonstrate a link with trauma, if individuals with calculus were typically frailer than those without calculus, they may have been more susceptible to sustaining trauma. However, rates of calculus within the non-adult hospital population were high (n = 797, 83%), and therefore, the development of calculus may be incidental to any sustained trauma.

The association between pathologies, trauma, and general stress indicators discussed here, creates a fuller understanding of the lives of non-adults buried at hospital sites. The combination of these factors suggests that many non-adults experienced prolonged episodes of malnutrition at a young age which weakened their immune system, predisposing them to more severe illness (Schroeder, 2008). In addition, malnutrition can result in lower cognitive functions, behavioural disorders, reduced productivity capacity, and an increased risk of mortality (Schroeder, 2008; Huffman and Schofield, 2011; Ayenigbara, 2013). In turn, causes of malnutrition are multi-factorial and inter-generational, with the highest levels today found amongst children born to parents of low economic and educational status, and to mothers who themselves had experienced malnutrition (Ayenigbara, 2013; Adebisi *et al*., 2019; Wells *et al*., 2020). Inmates of medieval hospitals were typically from the poorest or more deprived sectors of society (Gilchrist, 1995). This socio-economic status was associated in the medieval period, as it is currently, with multi-dimensional causative factors of ill-health including inter-generational low levels of nutrition and education, poor personal hygiene, and unhealthy living environments (Hanawalt, 2005; Redfern, 2012a). Thus, these were the social and economic environments non-adults had experienced when they entered hospitals. The various means by which hospitals offered support to these individuals forms the theme of the next section of this discussion.

6.3 Hospital Provisions

Tilley's (2015) 'Bioarchaeology of Care' model is adapted in the following discussion to infer the needs of non-adults with diseases or trauma, and the possible care provided within the context of a medieval hospital. This section will begin by considering the care required by those, who, due to their young age, were not physically capable, or deemed culturally able, to survive without the care of others. Following this, the degree of care needed by non-adults with certain pathologies and trauma will be discussed, and the potential of medieval hospital staff to treat or alleviate symptoms will be considered.

6.3.1 Provisions for Mothers and Juveniles

The under-representation of younger juveniles, particularly neonates, identified at medieval hospital sites is regarded as a common feature of archaeologically excavated medieval cemeteries (Mays, 2010a). Several factors can account for their low frequency in the archaeological record including differential burial practices, poor preservation rates of skeletal remains, and excavator error (Buckberry, 2000; Scheuer and Black, 2000; Mays, 2010a; Manifold, 2015), although, within a hospital context, cemetery demographics are further influenced by the types of inmates who were admitted. A woman who became pregnant outside of wedlock was considered morally corrupt and could be ordered by the Church and manorial courts to serve penance or pay fines (Lee, 2014). Nonetheless, despite any stigma attached to unwed mothers, most pregnant women with relatives to aid them, gave birth within the home (Orme, 2001; Lee, 2014). Women in poverty without familial support could have entered certain hospitals for support during childbirth. Yet, despite the high mortality risk for new-borns, the low numbers identified at most hospital sites indicate that many refused entry to pregnant women.

A statistically significant higher proportion of younger juveniles were reported from marginal sites compared to urban hospitals, yet demographics from individual hospital sites further indicate differences in admission and care policies. Non-adults are rarely recorded in hospital documents, and as such their presence cannot be easily explained. Orme and Webster (1995) suggest urban hospitals were likely to house younger children due to higher levels of urban poverty and mortality, resulting in more children being abandoned or orphaned. However, most urban hospitals excluded pregnant women from entry (Gilchrist and Sloane, 2005) and by extension, may have been less likely to provide care for new-borns. There were exceptions, for example, the hospital of St Bartholomew, London, accommodated babies from the nearby Newgate prison (Carlin, 1989). Thomas *et al*. (1997) suggests the high number of perinates from St Mary Spital, London, was due to the hospital's duty of care to pregnant women. If the mother died, this care extended to the child until seven years of age, when *infantia* (infancy) ended (Orme, 2001). The presence of pregnant women at the hospital is attested by bequests to them in wills (Harward *et al*., 2019), and from a papal indulgence to the hospital, dated A.D. 1445 which included the care of pregnant women and children, amongst its duties (Carlin, 1989). Redfern (2012a) proposes that low numbers of neonates from the site, was also due to the hospitals duty of care. The knowledge and experience of midwives and staff caring for pregnant women could have encouraged practices such as breastfeeding, thereby improving the survival of new-borns (Redfern, 2012a).

At another urban hospital, St Bartholomew, Newbury, a peak in mortality of one to five year olds and of adult females aged 18 to 25 years old was identified, and may also relate to childbearing (Witkin, 2006). Say *et al*. (2014) conducted a review of modern-day studies and identified complications during labour and delivery as the primary cause of maternal deaths, accounting for over one-third of cases. Additionally, the risks of a woman having a stillbirth are exacerbated by poverty and malnutrition, due to their impact on the health and development of a foetus (WHO, 2006b; Gowland, 2015). These examples indicate that certain urban hospitals did accept pregnant women in need of assistance, provided maternity care, and when necessary, burial, for women and their babies.

Conversely, St John's, Cambridge, is notable as its rule survives and specifically states the exclusion of pregnant women (Rubin, 1987). No individuals under five years of age were identified at this site, despite the presence of 61 older juveniles and adolescents (Dodwell, 2012). Dodwell (2012) suggests this demographic could relate to the hospital's entry policy, although possibly, this age group were buried in a separate area (see Section 6.4.2). Younger juveniles were not identified at St Mary, Ospringe (Bayley, 1979), or St Mary Magdalene, Partney (Anderson, 2010), which supports the hypothesis that certain hospitals did not accommodate younger children or had separate burial areas for them. Yet only five non-adults (24% and 15%, respectively) were identified at each of these sites and, consequently, the demographic may reflect excavation bias.

The financial costs of caring for orphaned or abandoned children may have prohibited certain hospitals from undertaking such care. Documentary sources from medieval hospitals in Milan (Italy) and Troyes (France) demonstrate that hospitals refused to accept abandoned children due to the costs involved and the fear of insufficient resources (Boswell, 1988). Cullum (1991) states the need for such care in England was far less than on the Continent, yet comparatively few English hospitals are documented as providing care for children. St Leonard's, York, is a well-documented exception. Visitation accounts indicate it housed 18 children, in a specific building where children were cared for by a sister, who was given provisions for their food and education (Cullum, 1991). Though, St Leonard's was atypical as it was one of the largest and wealthiest hospitals in England and was granted two churches in the mid-12th century as a means of providing for infants (Orme and Webster, 1995).

Gilchrist and Sloane (2005) suggest the higher proportion of adult females and non-adults identified at leprosaria may be related to the medieval beliefs that women were more susceptible to sexual sin, and sexual sin was a causation of leprosy. Consequently, single women who became pregnant, and their children, may have been forced to seek help at marginal sites. Marginal sites were typically leprosaria or almshouses which housed inmates on a long-term basis; married couples could enter leprosaria although accommodation was often segregated by sex (Bennike *et al*., 2005; Rawcliffe, 2006). Arrangements for children within these hospitals are not documented, although younger juveniles may have entered leprosaria for several reasons. Healthy children could be accommodated with a leprous parent to prevent them becoming destitute (Gilchrist, 1995; Lewis, 2002a). An account from early 19th

century Norway, describes a mother taking her son into a leprosarium with her for this reason (Richards, 1977). Children also accompanied their parents into leprosaria due to the fear by local communities, that they too could be contagious (*ibid*.). Additionally, children born to leprous parents could themselves exhibit soft tissue symptoms of leprosy by five years of age and may have been placed in leprosaria (Duncan *et al*., 1983; Lewis, 2002a).

Children could also be born within leprosaria to female inmates or the healthy partners of leprous men (Bennike *et al*., 2005). The chronic poverty of many inmates is illustrated by their need to beg for alms to secure their hospital place (Rawcliffe, 2006), and this degree of poverty would have contributed to higher levels of infant mortality. As stated above (Section 6.2.1.2) modern-day studies of the babies of women with Hansen's disease, found they are more susceptible to infections, and experience higher rates of mortality (Duncan, 1985; Sarkar and Pradhan, 2016). Pregnancy can cause an exacerbation of a mother's symptoms, including increased nerve function impairment which can continue postpartum and impact a mother's ability to care for her baby (Duncan, 2012). Consequently, a higher mortality rate for younger juveniles may be expected within leprosaria as opposed to urban general hospitals.

As younger juveniles grew older and became more independent of their family, they could leave a leprosarium if they had not contracted the disease. Although some may have decided to stay: an 18th century account from Finland reported the case of Brita Rasmonsdotter, who was taken into a leprosarium with her parents as a young child, and 16 years later remained there after her parent's death, although she was not leprous (Richards, 1977). Brita undertook chores within the hospital and was "ordered to look after the sick people" (Richards, 1977: 61). The provision of work or employment was an additional function of all hospitals which may explain the presence of some older juveniles, and the lack of any statistical significance in the numbers of this age group between types or locations of hospitals.

Historical records for hospitals in southern Italy demonstrate that they found employment for orphans in their care once they reached seven years of age, through external apprenticeships or within the hospital (Marino, 2015). A 15th century account from the infirmary of the monastery in Bury St Edmunds, Norwich, records mattresses being brought for boys who shared quarters with the sick (Rawcliffe, 2002). Rawcliffe (2002) suggests these boys looked after the sick in return for board and lodging. It is therefore possible that older juveniles would also have found work within hospitals in England. At St Mary, York, a hospital for poor priests, only two non-adults, both older juveniles, were identified from the cemetery excavation (Richards *et al*., 1989). Richards *et al*. (1989) suggest they may have been hospital staff or servants to the priests. Similarly, two older juveniles were reported from the site of St Mary and St Thomas, Ilford (Ingram, 2006). This hospital was founded for men only, and although the extent of the excavation was limited, the non-adult demographic supports Richards *et al*. (1989) hypothesis that older juveniles worked in hospitals.

Additionally, older juveniles potentially entered hospitals due to the institutions' association with monastic orders. Within the non-adult populations identified in this current study, St John, Berkhamsted was the only site from which a distinctly high proportion of older juveniles (31/46, 67%) were reported. Little is known about this site, and no historical documentation exists which could allude to the reason for such a high proportion of older juveniles. Hook (2021) identified a demographic peak of older juveniles within the non-adults (36/76, 47%) analysed from the cemetery population at the hospital of St James, located within the precinct of Thornton Abbey (Lincolnshire). Hook (2021) suggests they were possibly oblates: children given by their parents to a religious house and bound to monastic orders (Boswell, 1988; Orme, 2001). The practice of oblation continued into the 14th century, although it had declined in the 12th century following concerns over a child's right to choose a monastic life for themselves, and a rise in public schools which offered an alternative institution to which parents could send children to be educated (De Jong, 1996; Orme, 2001). Some hospitals also increased their educational provisions. For example, St Bartholomew's, London, and St Leonard's, York, provided education for foundlings, and later formally founded grammar schools (Draper, 2008). Price and Ponsford (1998) suggest that the conversion of St Bartholomew, Bristol, into a school in the 16th century, stemmed from an existing function of housing and educating children. Other hospitals provided daily alms to external scholars, and hospitals such as St John, Cambridge, provided accommodation to scholars from the colleges of Cambridge (Rubin, 1987).

Following the waning of oblation, the position of the tonsured clerk arose in monasteries (Orme, 2001). This was a secular post to which boys from the age of seven were admitted, performing liturgical duties such as singing and praying, and manual chores for example, fetching and carrying water, and dispensing alms (Orme, 2001; Hook, 2021). Orme (2001) suggests aristocratic families used oblation as a means of controlling inheritance, as oblates were prohibited from inheriting, although Boswell (1988) argues, oblation was also used by parents in poverty as a practical means of abandoning a child they could not afford to raise: placing them into an institution where the child would be housed, fed, clothed, and potentially given schooling. There is no documentary evidence relating to oblates or tonsured clerks within hospital contexts, however, the religious rule under which many hospitals operated, provided a suitable environment for the placement of juveniles, preparing for entry into a religious life.

6.3.2 Provisions for Disease

Manchester (1992) defines disease as an objective condition which can be observed and defined through pathology, whilst illness is subjective, defined by an individual’s experience and expression of disease. Within this section of the discussion, Tilley’s (2015) ‘Bioarchaeology of Care’ model is modified, to consider the diseases reported on the skeletal remains of non-adults from hospital sites, within the context of a person’s experience of disease and illness, using modern-day clinical studies. The duration of a non-adult’s residence within a hospital prior to death cannot be established, nor indeed, if they actually were an inmate. However, some degree of hospital accommodation is assumed for the non-adults buried within hospital sites. The resources available to hospitals varied between institutions and fluctuated over time as fortunes declined or flourished (see Chapter 2). Thus, the means and methods of care offered by medieval hospitals will be explored in general terms, with examples of specific care interpreted from documentary and archaeological sources.

6.3.2.1 Acute and Non-Specific Infections

Many of the non-adults (48%) buried within hospital sites, exhibited no osteological indicators of disease. It is therefore probable that many died from acute diseases which left no skeletal trace (Roberts and Manchester, 2010). Most modern-day studies of non-adult deaths caused by disease focus on the under five years of age group in developing countries (Black *et al*., 2003; Bryce *et al*., 2005; Liu *et al*., 2012). The Global Burden of Disease project has highlighted the scarcity of data on the causes of deaths in older juveniles and adolescents and is beginning to address this current gap in health care knowledge (Kyu *et al*., 2016). Clinical studies identified respiratory infections (specifically pneumonia), diarrheal disease, malaria, and intestinal infections as the most globally common causes of deaths in juveniles who survive the neonatal period (WHO, 1996; Bryce *et al*., 2005; Liu *et al*., 2012; Kyu *et al*., 2016; Reiner *et al*., 2019). Undernutrition was determined to be an underlying cause of death in approximately 50% of all deaths in children under five years old (Rice *et al*., 2000; Bryce *et al*., 2005). Furthermore, iron deficiency anaemia was identified as the leading cause of "years lived with a disability", in all non-adult age categories (Kyu *et al*., 2016: 277).

From the preceding discussion, it seems plausible that many non-adults from hospital sites experienced undernutrition and may have entered hospitals for care after contracting an acute disease. The symptoms these non-adults presented with would have been similar to those experienced by children today. Children with pneumonia can present with rapid or laboured breathing, a cough, fever, chest pain, and in severe cases with persistent vomiting, fatigue, convulsions, and unconsciousness (Clark *et al*., 2007; Scott *et al*., 2012; WHO, 2014). Without modern clinical intervention, death can occur within three days of the onset of illness (Källander *et al*., 2008). Children with diarrheal disease can also present with vomiting, convulsions, and fatigue, in addition to persistent diarrhoea, abdominal pain, weakness, and severe dehydration which can result in unconsciousness and death (Koletzko and Osterrieder, 2009; UNICEF and WHO, 2009; Godana and Mengistie, 2013).

A total of 196 non-adults from medieval hospital sites were reported with subperiosteal new bone formation, the majority of whom (128/196, 65.3%) only exhibited woven bone and thus, died with, and possibly due to, an active infection (Mays, 2010a). Although 10 of these non-adults were under five years of age and thus the woven bone may be attributable to normal growth. Therefore, the total number of non-adults over 5 years of age who exhibited woven bone was 118 (60.2%). A further 14 (7%) individuals displayed both woven and lamellar bone, indicating they died with a chronic, yet still active infection (Lewis, 2007; Mays, 2010a). These non-specific infections were probably localised, as illustrated by the discrete areas of subperiosteal new bone formation identified on the skeletal remains. Such infections can cause localised pain, inflammation, tenderness, and an increased temperature (Roberts, 2000a). If the infection spreads, complications could arise, including septicaemia and inflammation of internal organs, which in the pre-antibiotic era would have resulted in death (Hedrick, 2003; Mulholland and Adegbola, 2014).

Medieval hospitals, in accordance with the Seven Acts of Mercy, provided a bed, an adequate diet, and clothing, in a clean and warm environment (Carlin, 1989; Rubin, 1989). These provisions in themselves would have assisted the recovery from less severe illness. Importantly, most hospitals had access to clean running water (Gilchrist, 1995). The lay sisters and servants who provided care, could have washed inmates, cleansed wounds or lesions, and used water to help sooth fevers. Access to clean water would also have been vital for those suffering from dehydration. An unusual shaped bowl recovered from St Mary Spital, London, was interpreted by Egan (2007) as having a specific design which enabled the bowl to be held steady by a person’s foot as they fed a patient. Documents dating to A.D. 1259 from St Mark’s Hospital, Bristol (Avon), directed lay brethren to minister to the poor and assist inmates incapable of feeding themselves (Orme and Webster, 1995). It is therefore probable that staff at other hospitals would have assisted inmates who were weak, had painful limbs, or who were semi-conscious with their basic needs of eating and drinking.

Physicians are not recorded amongst hospital staff until the 16th century (Resl, 2008). However, akin to monasteries, many brethren and sisters in hospitals had knowledge of herbal remedies such as those contained in the *Old English Herbarium* and the *De Viribus Herbarum* (Concerning the Power of Herbs) (Moffat, 1988; Meaney, 2000; Van Arsdall, 2007). A range of medicinal herbs (for example, dill, St John’s wort, henbane, and fever-few), and traces of metals (such as copper, arsenic, and mercury), used in medicines have been identified from archaeological excavations at hospital sites in Britain (Cardwell, 1996; Moffat, 2014; Harward *et al*., 2019). Herbs were blended with honey to make syrups and salves, and medicines with laxative, diuretic, sedative, or stimulant qualities, were likely administered to treat a range of illnesses (Gilchrist, 1995; Harward *et al*. 2019). Medieval medicine was based on the ancient Greek and Roman belief that the four humours of the body (black bile, yellow bile, blood, and phlegm) needed to be balanced (Rawcliffe, 1995). Many of these herbal remedies purged the body of any excess humour which caused illness (Roberts and Buikstra, 2003). The use of leeches and bloodletting was regularly practiced within monastic institutions to balance the humours of brethren, and it is therefore likely to have been conducted in hospitals (Harward *et al*., 2019). Illness was also considered a physical expression of sin in the medieval mind; hence, spiritual healing was deemed crucial if physical relief was to be obtained (Rawcliffe, 1999; Horden, 2007). Consequently, the religious environment of most medieval hospitals, where inmates were within sight of relics, could hear mass, receive the sacrament, and confess, aided the care of inmates during life, and for those not able to recover, prepared them for a ‘good death’ (Carlin, 1989; Gilchrist, 1995; Rawcliffe, 1999; Horden, 2001).

6.3.2.2. Chronic and Specific Diseases

The findings of this current research suggest that many non-adults who entered hospitals had chronic diseases or health conditions which persisted long enough to create evidential skeletal markers. Thus, in addition to the care aforementioned, these non-adults would have required longer-term and possibly more skilled care. The two most frequently reported specific diseases (excluding dental disease) in non-adults from the hospital sites are discussed here: TB (n = 33) and leprosy (n = 24). Treponemal disease is also discussed, due to its importance within the discourse of medieval disease, as evidence for syphilis in Europe prior to A.D. 1500 is scarce (Roberts and Manchester, 2010). In total, four non-adults from medieval hospitals were reported with indicators of treponemal disease, or venereal syphilis, and another three were recorded as exhibiting evidence of congenital syphilis.

In addition to the cough and chest pain associated with TB, impairments to lung function, weight loss, wasting, and fatigue are common symptoms (Marais *et al*., 2005; Maguire *et al*., 2009). As the disease progresses, osteomyelitis of the spine can occur, and other joints and bones become affected: abscesses develop in joints and joint surfaces can be destroyed, eventually causing ankylosis (Roberts and Manchester, 2010). The affected vertebrae can collapse, producing kyphosis, an angular deformity of the spine, compressing the spinal cord, potentially causing weakness, numbness, or paralysis of the lower limbs (Lewis, 2008; Roberts and Manchester, 2010). The destruction of bones and joints further results in declining mobility and dexterity, and a dependence on others for survival (Redfern, 2012a).

In a study of children with TB, conducted in Britain in the early 20th century (prior to antibiotics), Fraser (1914) recommended a hygienic environment, clean air, and a good diet, as general treatments for TB. Cod-liver oil, iron, arsenic, and mercury were suggested as beneficial drug treatments (Fraser, 1914). Medieval hospital inmates would have benefitted from a clean environment and a regular diet including fresh fruits and vegetables. Milk from a variety of animals was recommended to improve the strength of tuberculous patients in the 14th century (Roberts and Buikstra, 2003). Finds of cattle, sheep, and goat bones from hospitals such as St Mary Spital, London, suggest different milks were potentially available to inmates (Reilly, 2019). Trace metals of arsenic and mercury were identified from hospital sites and may have been used in the medicinal treatment of TB. Fraser (1914) advocated fixing the affected body part with a plaster cast or splint, for a minimum of 12 months. Knowledge of limb stabilisation in the medieval period is inferred from the apparent successful healing of fractures (see Section 6.3.3). Although osteology reports often refer to a fracture as 'healed', indicating the growth of new bone, rather than stating if the bone was well-aligned which would suggest intervention and treatment. Nonetheless, it is possible that immobilisation treatments were used with tuberculous inmates. Consequently, these inmates required support for a lengthy time and would have needed assistance with mobility, although some may have adapted to their condition, using crutches or other aids (Redfern, 2012a). During the medieval period, scrofula, a form of TB which enlarged the lymph glands in the neck, was believed to be cured by 'touching for the King's Evil' (Roberts and Buikstra, 2003; Roberts and Manchester, 2010). In both England and France, the king or queen would touch a person with TB and give them a gold touch-piece, believed to cure the condition (Barlow, 1980; Roberts and Buikstra, 2003). A group of seven such coins from the reign of Henry VIII were excavated at St Mary Spital, London (Egan, 2019). These coins were known as 'angels' and may have been given to inmates as part of a "spiritual armoury" against TB (Egan, 2007: 70).

All of the 24 non-adults identified with leprosy in this current study, were from sites which originated as leprosaria. Cases of leprosy were identified in a statistically significant higher proportion of adolescents than juveniles, reflecting the slow progress of the disease which has an incubation period of three to five years (Gilchrist, 1995; Roberts and Manchester, 2010). The symptoms vary depending on the type of leprosy (tuberculoid or lepromatous leprosy) and the immune system of the individual (Lewis, 2002a; Stone *et al*., 2009; Roberts, 2011; Roffey and Tucker, 2012). Leprosy affects the peripheral nerves, typically affecting the face and extremities, causing skin lesions, numbness, pain, swelling, sensory disturbance and blindness, finger contracture, muscle atrophy, paralysis of the limbs, and motor dysfunction, resulting in disfigurement and disability (Roberts and Manchester, 2010; Chen *et al*., 2021). The loss of sensation in the extremities can lead to trauma and injury, leading to the loss of digits due to infection, sepsis, and bone absorption (Rawcliffe, 2006). Thus, people with the disease had various degrees of symptoms, which determined the level of care they required.

Masters of leprosaria, and the brothers and sisters who entered leprosaria, were often leprous themselves (Rawcliffe, 2006). Consequently, many leprosaria were self-contained leprous communities, with those less afflicted caring for inmates at a more advanced stage of the disease. The stigma and ostracism that leprous individuals experienced in the wider society, may have been alleviated by becoming part of a leper community (Roberts, 2011). The healthy spouses of leprous individuals could also enter leprosaria (Rawcliffe, 2006), as evidenced in historical accounts from Næstved, Denmark, which attest to "womenfolk" of leprous individuals, entering leprosaria to care for them (Bennike *et al.*, 2005: 736). Professional medical assistance may have been available at certain institutions: financial accounts from St Mary Magdalene, Reading (Berkshire), indicate a barber visited the leprosarium, possibly performing treatments such as bloodletting (Phillips, 2013). Phlebotomy was a recognised form of treatment for leprosy in the medieval period and was believed to balance the humours and aid recovery (Demaitre, 1996), and may have been widely used in hospitals.

Diet was also considered important in balancing the body's humours (Demaitre, 1996; Brenner, 2010). Situated on the outskirts of towns, most leprosaria had enough land to be relatively self-sufficient (Rawcliffe, 2006; Roffey, 2012). The livestock kept by leprosaria, their fishponds, and vegetable gardens, provided inmates with appropriate and healthy foodstuffs (Brenner, 2010; Phillips, 2013). Garden herbs were also grown and used for medicines: the leprosarium at Harbledown, Kent, was renowned by herbalists for its collection of medicinal plants (Rawcliffe, 2006). Phillips (2013) suggests brethren at the leprosarium in Reading also used the hospital's animals for treatments, using pig fat to make ointments for skin conditions. Rawcliffe (2008) argues that medieval gardens were themselves, a source of medicine. Fresh air was advocated for the leprous by physicians, and the experience of seeing colours, smelling perfumes, and hearing bird song, were beneficial to health and healing (Demaitre, 1996; Rawcliffe, 2008). Within leprosaria, the value of these sensual experiences was apparent for inmates who had lost one sense of touch or sight. Additionally, for inmates who were capable, which likely included non-adults, the exercise provided by light gardening activities was considered beneficial to prevent the development of phlegmatic humours, and to combat "the sins of idleness and depression" to which the leprous were believed to be prone (Rawcliffe, 2008: 16).

To date, there is no evidence for piped water to leprosaria as there is for general hospitals, although many leprosaria were located next to rivers, springs, or wells, whose waters were believed to have healing properties (Brenner, 2010; Roffey, 2012). Bathing in these waters or in herbal baths, was recommended by medieval physicians and would have been physically soothing (Roffey, 2012). Moreover, water was associated with baptism and the cleansing of the soul. A Bible story, 'The Healing of Naaman the Syrian' (2 Kings 5: 1-27) recounts how God cured a leper, Naaman the Syrian, after he bathed in the River Jordan seven times (Gilchrist, 1995). As the causes of leprosy were intricately linked with sin, purification rituals were associated with a spiritual rebirth (*ibid*.). The significance of religion in leprosaria was affirmed in a decree of the Third Lateran Council of A.D. 1179, which stated that leper communities should have their own independent priest (Roffey, 2012). The infirmary and chapel within leprosaria were often housed within the same building, emphasising the importance between the physical body and spiritual care (Rawcliffe, 2006; Roffey, 2012). Rawcliffe (2006) further suggests that the liminality of leprosaria was itself, a means by which these hospitals removed inmates from the polluting influence of the outside world and maintained a peaceful healing environment of prayer and contemplation to aid inmates.

In Roberts and Cox's (2003) study of disease in medieval England, only five individuals from archaeological contexts were identified with syphilis, a further two with potential syphilis, and nine with treponemal disease. The seven non-adults considered in this current research exhibiting congenital or venereal syphilitic lesions were from three hospital sites, namely St Bartholomew, Newbury (Clough and Witkin, 2006), St Giles, Lincoln (Lincolnshire) (Allen Archaeology, 2012), and St Mary Spital, London (Connell *et al*., 2012). These sites were excavated after Roberts and Cox's (2003) publication and are therefore an important additional contribution to the study of this disease. Syphilis only manifests permanently on the bone during the final tertiary stage of the disease, by which time the effects on health are severe (Roberts and Cox, 2003). The initial symptoms of syphilis are a localised ulcer and generalised inflammation, followed months later by the secondary stage during which fever, rashes, fatigue, lesions, meningitis, and non-diagnostic skeletal lesions can occur (Zuckerman, 2016). A tertiary stage arises, often after years of remission, during which gummas lesions form on the face and head, the mucous membrane, the skeleton, the cardiovascular and nervous systems, and internal organs (Kępa *et al*., 2012). This can result in aortic aneurysm, total paralysis, mental disorders, blindness, and epilepsy (Kępa *et al*., 2012; Zuckerman, 2016).

An infant from St Bartholomew, Newbury, exhibited developmental abnormalities consistent with congenital syphilis (Witkin, 2006). Modern-day studies of neonates with congenital syphilis have reported symptoms of rashes, fevers, jaundice, and meningitis, presenting within four months of birth (Dorfman and Glaser, 1990; Rocha *et al*., 2021). Neonates and infants born with congenital syphilis are at an increased risk of death, and are vulnerable to secondary infections, for example, TB and pneumonia (McDermott *et al*., 1993; Krüger and Malleyeck, 2010). Boswell (1988) suggests that disfigurement or ill-health were reasons for the abandonment of babies during the medieval period. The child from St Bartholomew, was possibly born at the hospital or given into its care when symptoms began to appear, and congenital syphilis was potentially an underlying cause of this infant's premature death.

The three non-adults (one older juvenile and two adolescents) from St Mary Spital, London, who exhibited skeletal changes consistent with venereal syphilis, were thought to be in the tertiary stage of the disease, whilst an adolescent from St Giles, Lincoln, was possibly in the secondary stage (Allen Archaeology, 2012; Connell *et al*., 2012). Connell *et al*. (2012) suggest that due to the advanced stage of the disease, the three non-adults from St Mary Spital needed to rely on others for their basic needs. As aforementioned, within hospitals, inmates were under the observation of staff who provided daily physical and spiritual care, and could administer herbal medicines or practised bloodletting, to ease symptoms (Ros-Vivancos *et al*., 2018). Sefton (2001) suggests early treatments for syphilis included burning sores with hot irons. Cauterisation was used to treat different illnesses during the medieval period (Walker, 2012a), and therefore its use in the treatment of syphilis is possible.

Mercury was used medicinally through the medieval period and was advocated by surgeons in the 13th century as a cure for skin lesions and leprosy (Ros-Vivancos *et al*., 2018). It became a popular treatment for syphilis from the early 16th century, when it was routinely prescribed in a series of treatments in which it was taken as an oral liquid, applied to the skin as an ointment, and the vapours inhaled (Zuckerman, 2016). Trace elements of mercury from the skeletal remains of adults with syphilitic lesions have been identified from early 15th century Poland and medieval Denmark, indicating they received mercurial treatments (Rasmussen *et* *al*., 2008; Kępa *et al*., 2012). The non-adults identified with syphilis from St Mary Spital, were buried during the later phase (A.D. 1400-1539) of the hospitals existence, and traces of mercury were identified at the hospital (Connell *et al*., 2012; Harward *et al*., 2019). Thus, it is possible that mercury was a recognised treatment for syphilis at this time and was used in the care of these non-adults.

There were no known effective cures in the medieval period for the infectious diseases discussed above (Roberts, 2011). Nonetheless, non-adults who possibly experienced malnutrition, lived in unsanitary, overcrowded accommodation, and were living with symptomatic illness, would have benefitted from the diet, warmth, bed rest, and personal care offered by a hospital. Some non-adults who sustained an injury would also have required institutional assistance, and the treatment of fractures is the final subject in this section of the discussion.

6.3.3 Provisions for Trauma

The majority of fractures (27/36, 75%) in the non-adult hospital population were reported to have 'healed' prior to death. Although as discussed above (Section 6.3.2.2) most osteology reports do not state the alignment of the bone which could be used more directly to infer treatment, only whether the bone had 'healed' indicating the fracture occurred prior to death. Only two (6%) non-adults were reported with 'non-healed' fractures, an older juvenile, and an adolescent from St Mary Spital, London, who both exhibited rib fractures. No other pathologies were reported in relation to the fractures; thus, these individuals may have died due to fatal soft tissue injuries within the area of the rib cage (Lovell, 1997; Walker, 2012a). Skeletal evidence of healed fractures comes from hospital sites and contemporary parish and monastic cemeteries, including St Helen-on-the-Walls, York (North Yorkshire) (Grauer and Roberts, 1996), Wharram Percy, Malton (Mays, 2007), East Smithfield, London (Cowal *et al*., 2008), and Stoke Quay, Ipswich (Essex) (Gibson *et al*., 2020). These examples demonstrate that union of the bone was successful in many cases, although malalignment was observed in some individuals (Grauer and Roberts, 1996; Walker 2012a). Evidently, bone manipulation and immobilisation of fractures was practiced in the medieval period. Professional 'bone setters' are documented in medieval Europe, although whether they were employed by English hospitals is unknown (Grauer and Roberts, 1996). Walker (2012a) compared fracture healing patterns in adults from the hospital sites of St Mary Spital, London, and St James and St Mary Magdalene, Chichester, with the parish site of St Helen-on-the-Walls, York. Successful healing was identified more frequently in those from hospital sites, hence, Walker (2012a) proposed that medieval hospitals had more skilled staff or better resources than the wider community.

Methods to treat fractures were published by European surgeons, such as Guy de Chauliac (A.D. 1300-1370) and Hieronymus Brunschwig (A.D. 1450-1533), and were translated into English (Clark, 1937). Such treatment involved several stages: firstly, the reduction of the fracture by suction, manual extension, or if necessary, mechanical apparatus. Secondly, the application of herbal ointments, followed by the use of splints made from willow, wood, horn, iron, or leather, wrapped in cloth moistened with egg white, which stiffened the bandage to restrain the bone. Finally, slings or a cradle were used to permit the limb to rest (*ibid*.). Traditional bonesetters in Nigeria and Ghana today, successfully heal closed long bone fractures using similar methods: manipulating the bone, massaging the area with shea butter, applying herbs, and immobilizing the fracture with mats made from wooden sticks or plantain leaves, or using hard carboard or plywood as splints (Onuminya, 2004; Ariës *et al*., 2007; Nwachukwu *et al*., 2011). Clinical studies have highlighted complications, including ulcers and non-union, experienced by fracture patients who visited traditional bonesetters (Alonge *et al*., 2004; Panigrahi *et al*., 2017; Warman *et al*., 2018). However, these studies are primarily based in clinical hospitals, and consequently only assess attending patients. Therefore, determining the success rate of the traditional bonesetter is problematic.

Most non-adults from the hospital populations received sufficient care to enable their fractures to heal, although it cannot be established whether the fractures were treated within the community or the hospital. Mays (2007) argues that evidence of successful healing does not necessarily equate to treatment, as studies of wild apes has demonstrated fractures can heal with minimal deformity without intervention. In humans too, the radius can act as a natural splint for ulna fractures, and the tibia performs the same function for fibula fractures (Grauer and Roberts, 1996). Grauer and Roberts (1996) identified varying levels of successful healing at St Helen-on-the-Walls, York, even within the same individual, which they argue, raises doubts as to the presence of treatment, or the necessary skill involved in the reduction of fractures.

The duration for a fracture to heal varies, typically taking one to six months, dependent on the type of bone and fracture involved (Lovell, 1997). Malnourishment and an individual’s general level of health also affect the period of healing (Walker, 2012a). Sufficient rest time is crucial in allowing a fracture to successfully heal (Lovell, 1997). If a non-adult was unable to work for a prolonged time, they may have turned to hospital charity. Moreover, fractures and the complications associated with them can cause significant pain. Hospital staff could administer herbal remedies incorporating opium and henbane to relieve pain (Rawcliffe, 1995). Additional treatments possibly included the use of copper-alloy plates, which were identified in adult burials from St Mary Spital, London (Walker, 2012a). These were interpreted as bracing to support joints, or as a dressing treatment, used to hold a poultice in place (Walker, 2012a). Such objects have not been found in relation to non-adults, however, it is plausible similar methods may have used within hospitals to assist non-adults recovering from trauma.

Multiple complications can occur with a fracture, including non-union or malunion of the bone, secondary infections, nerve damage, paralysis, and secondary osteoarthritis (Lovell, 1997; Roberts and Manchester, 2010). The mobility or functioning of the affected body part could be impaired, potentially on a permanent basis (Lovell, 1997), resulting in the need of extensive and prolonged hospital care. A possible male adolescent from St Mary Spital, London, was identified with a healed fracture to the right tibia: the distal end was enlarged, and a partially fused mis-shaped epiphysis was also recorded. Active subperiosteal new bone formation on the tibia and fibula were observed, indicating this individual continued to experience difficulties related to the fracture up to the time of death (Centre for Human Biology, 2013). In such instances, a non-adult may have required hospital care beyond the initial healing of the fracture.

The types of care discussed above, would have alleviated some of the physical symptoms of illness experienced by non-adults. The care and attention given by staff and potentially other hospital inmates may also have relieved emotional aspects of enduring ill health or trauma. The spiritual wellbeing of non-adults was of paramount importance within hospitals, and this too was aided through the religious practices and environment of these institutions. Ultimately, however, the non-adults considered in this current research died before reaching maturity. For these individuals, hospitals performed their final duty of the Seven Works of Mercy: namely, burial of the dead. This is the theme of the following and final section of this discussion.

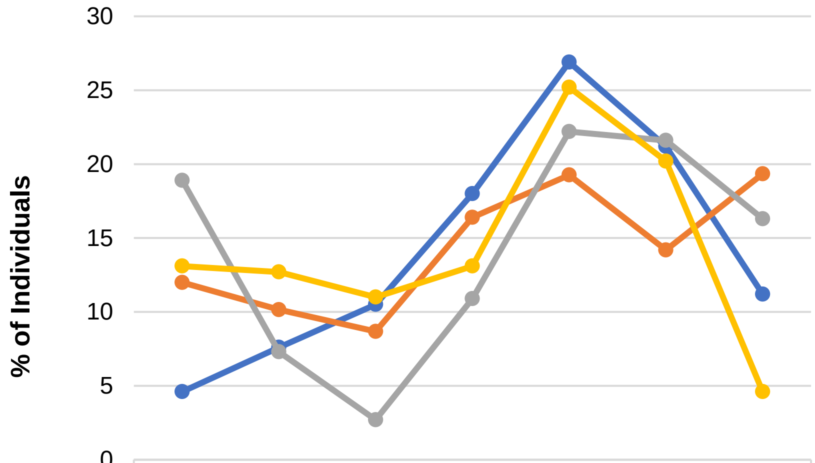
6.4 Burial Practices for Non-adults at Medieval Hospital Sites

Most non-adults identified in this current study were buried in accordance with standard medieval Christian burial practices: they were interred with the same care afforded to adults, placed supine in individual graves, orientated on a west-east alignment, with no deliberate inclusion of grave goods (Dawson, 2017). The main exception to this practice, were the multiple inhumations within large burial pits, identified at St Mary Spital, London, who were thought to be victims of early 14th century famines (Connell *et al*., 2012). Anomalies within burial practices have been observed which are discussed below, including the zoning of burials by age, the use of coffins, and multiple burials.

6.4.1 Cemetery Demographics

The reasons for non-adults from differing age groups entering different types of hospitals has been discussed above. Here, the combined non-adult demographics of the 27 hospital sites considered in this current research are examined. Cemetery demographics are categorised using two mortality profiles. The attritional model reflects mortality risks under most circumstances, in which all age categories are present, with elevated mortality in the youngest and oldest within a population (Chamberlain, 2006). This profile is typically observed in a parish cemetery, for example, the medieval site of St Helen-on-the-Walls, York (Appendix 4) (Dawes and Magilton, 1980). In catastrophic mortality profiles, an elevated risk of mortality is evident for all age groups (Chamberlain, 2006), as observed in the Black Death cemetery of East Smithfield, London (Appendix 4) (Cowal *et al*., 2008). Within the hospital populations, younger juveniles account for the lowest proportion of non-adult burials, with increasing numbers of older juveniles, and adolescents comprising the greatest number (Figure 6.1.1). This is the opposite of an attritional mortality model, although, it does not conform to a catastrophe profile either (Gowland and Chamberlain, 2005). The hospital profile is reversed to some degree, when the data from St Mary Spital, London, are removed, thus, supporting the hypothesis that London was a particular draw for adolescents seeking work (Redfern, 2012a).

Figure 6.1.1 illustrates the unique mortality profile of individuals buried at St Mary Spital, London which strongly influences the mortality pattern seen for ‘All hospitals’. When the St Mary Spital data is excluded, a hospital non-adult mortality profile is evident which closely mirrors that seen in the East Smithfield cemetery, London. Following from the discussion above, it can therefore be inferred that non-adults from all age categories who entered hospitals were at an elevated risk of mortality compared to those in the wider population, potentially due to socio-economic factors, malnutrition, and disease.



	Birth-5 years	6-11 years	12-17 years	18-25 years	26-35 years	36-45 years	+46 years
All Hospitals	4.6	7.6	10.5	18.0	26.9	21.2	11.2
Hospitals exc Mary Spital	12.0	10.2	8.7	16.4	19.3	14.2	19.3
St Helen-on-the-Walls, York	18.9	7.3	2.7	10.9	22.2	21.6	16.3
East Smithfield, London	13.1	12.7	11	13.1	25.2	20.2	4.6

Figure 6.1.1 Mortality profiles of hospital cemeteries (including and excluding St Mary Spital, London) compared to two non-hospital cemetery sites.

6.4.2 Burial Locations

Most individuals buried at hospital sites were recorded in areas thought to be cemeteries associated with the hospital (e.g. Clough and Witkin, 2006; Cessford, 2012; Connell *et al*., 2012; Goacher *et al*., 2016). During the medieval period, burial in or near a chapel was considered spiritually preferential and held great religious significance (Gilchrist and Sloane, 2005). At three hospital sites, all the non-adults identified were located within a chapel: St Bartholomew, Bristol (n = 7) (Price and Ponsford, 1998), St Mary, Castleton (n = 2) (Bloxham, 2013), and St Mary, York (n = 2) (Richards *et al*., 1989). Price and Ponsford (1998) suggested the lack of non-adults from elsewhere at these sites may reflect the limited extent of excavations. Alternatively, Richards *et al*. (1989) propose that non-adults were not inmates at these sites and consequently few were buried. As aforementioned (Section 6.3.1), Richards *et al*. (1989) suggest two juveniles from St Mary's, York, were servants working in the hospital, although their burial within the chapel suggests they were of high status. However, a family connection to St Mary's, potentially to a hospital benefactor, may explain the privileged location of burial for the two juveniles at this hospital.

A single adolescent from St Mary Magdalene, Winchester, was identified within the cemetery chapel (Tucker, n.d.). This individual exhibited cribra orbitalia, indicating they experienced childhood dietary deficiencies. The degree of dietary deficiency is arguable though, as due to the nature of the secondary osteology data used in this thesis the severity, or grading, of cribra orbitalia is unknown and the cause of orbital lesions may be attributable to other factors. Similarly, two non-adults from the chapel at St Bartholomew, Bristol, were reported with cribra orbitalia and DEH (Stroud, 1998). Poor levels of nutrition are not generally associated with individuals of a higher social status. However, whilst wealthier individuals can be buffeted from famines exacerbated by economic factors, these three non-adults possibly experienced more extreme episodes of famine which result in mass starvation affecting all levels of society (Slavin, 2014; Horocholyn and Brickley, 2017). However, Price and Ponsford (1998) suggest the church at St Bartholomew, Bristol, was used for adult and non-adult burials after land adjacent to the cemetery was leased: thus, the location of the burials here were possibly due to financial prudence rather than social status.

The burial of stillborn or unbaptized infants in consecrated ground was prohibited by the Church, as they were believed to have inherited but not been cleansed of, the Original Sin (Crow *et al*., 2020). The archaeological excavation at St Mary Magdalene, Bawtry, was conducted adjacent to the chapel walls, which the excavators believe may explain the high proportion of under four-year-olds identified at the site (15/34, 44%) (McIntyre and Hadley, 2012). Similarly, two of the five non-adults from St Mary Magdalene, Partney, were buried next to the church walls. In both instances the excavators considered that the locations of the burials indicated a continuation of the early medieval practice of 'eaves-drip' burial, whereby water running off the church roof would 'double-bless' the children (Atkins and Popescu, 2010; McIntyre and Hadley, 2012; Craig-Atkins, 2014). This may have been deemed particularly important to ensure the baptism rites of younger juveniles were observed.

Holder (2019) suggests changing social attitudes to the burial of the unbaptised, is seen at St Mary Spital, London, where a high proportion of perinates and neonates were identified in a cemetery chapel, built *c.* A.D. 1400 (Holder, 2019). Holder (2019: 203) suggests the dedication of this chapel to St Anne, the mother of Mary and a saint often portrayed with children, indicates a new "more humane attitude" towards the burial of the very young and a desire to assist their passage to heaven. A preaching cross in St Mary Spital cemetery was another focal point for the burial of infants (Holder, 2019). Those conducting the burials possibly considered that this hierarchically more sacred space, brought infants closer to God and heaven (Hausmair, 2017). Conversely, Holder (2019) suggests this was a space deliberately left un-consecrated to allow burial of the un-baptised within the cemetery. The concept of a *cillin*, or liminal burial space for children and those deemed ineligible for burial within consecrated ground, has been recognised in medieval and modern sites in Ireland (Channing and Randolph-Quinney, 2006; Nolan, 2006; Dennehy, 2016). These areas may have been acceptable to the Church as burial places for the unbaptised, whilst serving as important sacred spaces to the families of those buried there (Murphy, 2011). The burials near the preaching cross at St Mary Spital potentially indicate that a similar practice also occurred in England.

The graves in most of the cemeteries considered in this current research, were dug in linear rows, with a new row commencing once the limit of the cemetery area was reached. Individuals were inhumed in succession as they died, resulting in no apparent zoning of burials by age or sex. At some sites, however, areas of the cemeteries were favoured by, or allocated to, certain groups of individuals. For example, at St Mary Magdalene, Partney, a path divided two types of burials distinguished by status: to the north, where all of the non-adults were recorded, simple shallow earth-cut graves were encountered, and were interpreted as lay burials (Atkins and Popescu, 2010). To the south of the path, deeper anthropomorphic cut graves were identified and thought to be the burials of monks (*ibid*.). Similar examples of distinct burial areas for a religious community and laity have also been identified in France and Italy (Augenti and Gilchrist, 2011). Archaeological excavations at a site associated with the hospital of St Peter's, Bury St Edmunds, were conducted in two phases. The first uncovered an area containing the burials of 12 adults, whilst the second, in an adjacent residential property identified five non-adults (Anderson, 2003; Brooks, 2012). Chapman's (2015) study of English medieval parish cemeteries concluded zoning of burials by age, particularly of infants and juveniles, was a common practice. The limited extent of the excavations at St Peter's prohibits any definitive assessment of burial practices, but the identification of non-adults in a discrete group, suggests zoning by age may have been practised at this site.

Definitive zoning of juvenile burials was observed in the cemetery of St James and St Mary Magdalene, Chichester (Magilton, 2008b). Older juveniles and adolescents were buried within the cemetery rows with adults, whilst most younger juveniles, up to seven years of age, were buried in an area forming a band along the south-east boundary of the cemetery and many infant burials were clustered in a second area, within an inner ditch (*ibid*.). Magilton (2008b) argues the ditch may have formed an earlier cemetery boundary, prior to an expansion of the cemetery. This organisation of non-adult burials was not observed at any other medieval hospital site. Although, no under five-year-olds were identified at St John's, Cambridge, where 61 older juveniles and adolescents were recorded (Cessford, 2012). Cessford (2012) argues, they may have been missed during excavation due to the practice of burying younger juveniles at the cemetery fringe. This practice may reflect local or regional beliefs and traditions as zoning of infant burials along boundary walls and ditches has been identified in lay cemeteries at monastic sites (Gilchrist and Sloane, 2005).

6.4.3 Coffin Burials

The use of coffins for the burial of non-adults was identified at only six hospital sites.[6] These sites are distributed across England, reflecting local rather than regional variations in burial practices (Gilchrist, 2012). The rate of non-adults given coffin burials at these hospitals was typically between 20% and 30%. However, 79 of the 97 (81%) coffined burials identified in this current study, are from the single site of St James and St Mary Magdalene, Chichester, where 75% of non-adult burials contained nails, which the excavators interpreted as indicating the use of coffins (Magilton *et al*., 2008). A high incidence of coffin use was identified at the East Smithfield Black Death cemetery, which Gilchrist and Sloane (2005) suggests, indicate a correlation between coffin use and disease. The medieval belief that disease could spread through the miasma of un-coffined corpses, could explain the greater use of coffins at certain sites (Magilton, 2008a). Magilton (2008a) suggests the application of this belief to leprosy, could also explain the high prevalence of

[6] Sites where coffins were identified: 1. St Bartholomew, Bristol; 2. St Bartholomew, Newbury; 6. St Leonard, Peterborough; 16. St Mary Magdalene, Winchester; 32. St Mary Magdalene, Bawtry; 40. St James and St Mary Magdalene, Chichester.

coffin burials at St James and St Mary Magdalene, Chichester. However, the use of coffins increased at this site after the leprosaria was re-founded as an almshouse. Alternatively, a ‘good burial’ could have been a privilege of entry to this particular hospital (Magilton, 2008a). Conversely, differing burial practices based on age and sex may be implied: the leprosarium predominantly housed men, whereas women and children were inhabitants of the almshouse (*ibid*.). Gilchrist and Sloane (2005) identified a higher rate of coffin use for women and children compared to males in medieval monastic cemeteries. They suggest this may be related to the concept of the four humours: women and children were believed to be excessively wet, more prone to putrefaction after death, and thus, needed greater protection from the earth, necessitating a coffin burial (Gilchrist and Sloane, 2005). The end of the *infantia* stage in medieval childhood at seven years of age (Orme, 2001), may have marked a change in how non-adults were viewed, resulting in a change of burial practices for non-adults after this age threshold had passed.

This belief may be evidenced within the hospital data, as a statistically significant higher proportion of younger juveniles were buried within coffins compared with older juveniles or adolescents. The use of coffins for the burial of neonates, infants, and young children did not differ statistically, suggesting that burial practices for under five-year-olds was consistent. Children are absent from almshouse records, although institutions such as St James and St Mary Magdalene, Chichester, possibly housed family units (Magilton, 2008a). Orme (2001) provides examples of accounts of the grief felt at the death of children and the burials afforded to those of middling and aristocratic families, whilst stating that poverty or the frequency of infant deaths, would not have lessened the pain felt by parents. Families who lost younger children may have been more likely to provide them with a ‘proper’ burial, which included interment in a coffin, although the cost was prohibitive for most poor families (Orme, 2001). Alternatively, non-adults who died in general hospitals may have been abandoned or arrived there independently of any family. Consequently, it was the responsibility of the institution to conduct burials, and at most sites, the data suggests that either the cost of coffins was prohibitive, or the use of coffins was not considered necessary.

Another feature of burial practice, predominantly identified at St James and St Mary Magdalene, Chichester, was the use of ‘ear-muffs’. Pairs of stones placed either side of the head were identified in 39 burials, including those of nine non-adults (Magilton *et al*., 2008). The same practice was observed in seven adult burials at the hospital of St Nicholas, Lewes (Barber and Sibun, 1998). The custom has also been identified in adult burials at parish and monastic sites including St Oswald, Gloucester (Gloucestershire), and St Peter and St Grimbald, Winchester (Hampshire) (Heighway and Bryant, 1999; Gilchrist and Sloane, 2005). An adolescent, buried with a possible 'ear-muff' has been recorded from only one other medieval site, St James's Priory, Bristol (Gilchrist and Sloane, 2005).

The placing of stones around or on either side of the head was practised in a minority of burials during the latter early medieval and Norman periods, declining during the 12th century as burial practices were simplified (Daniell, 1997; Heighway and Bryant, 1999; Gilchrist, 2012). The meaning of the stones is uncertain: they may have had a purely practical purpose of stabilising the head, visually framed the head, represented a form of penance, or held spiritual significance if they came from a sacred place (Gilchrist and Sloane, 2005; Jackson, 2006; Magilton, 2008b). Daniell (1997) suggests the emphasis on the Resurrection in the 10th-12th centuries may explain the importance of 'ear-muffs' in ensuring the head faced east on the Day of Judgement. The later date of the use of 'ear-muffs' at St James and St Mary Magdalene, Chichester, could indicate a continuation of this belief. The use of 'ear-muffs' appears to be dictated by localised practices as no patterning by age or sex was apparent at St Oswald, Gloucester (Heighway and Bryant, 1999), although at other sites their use for predominantly adult males (Raunds, Barton-on-Humber), or alternately, females (St Nicholas Shambles, London), has been observed (Daniell, 1997). These differences in burial practices for particular social groups could relate to age, wealth, social status, or religious orthodoxy (Gilchrist, 2012). A hypothesis of a local burial tradition may be applicable at St James and St Mary Magdalene, Chichester, as with the exception of two infants, the non-adults buried with 'ear-muffs' were all five to 12 years of age. This roughly corresponds with the medieval life stage of *pueritia,* indicating this mortuary rite was reserved for certain non-adults at this phase in life.

6.4.4 Multiple Burials

Multiple burials were relatively rare in medieval burial practices (Cessford, 2012). They have been identified in at least five of the 11 non-hospital sites (Appendix 4) and typically involve multiple non-adults or at least one non-adult interred with adults (Dawes and Magilton, 1980; Mays, 2007). Multiple burials could incorporate individuals who were interred simultaneously or involve the re-use of the same grave plot after the initial interment (Gilchrist and Sloane, 2005). The practices of interring multiple individuals within a single grave are explored in this section, and may have occurred for many reasons, including the desire of family members to be buried together, a practical means of managing burials during an outbreak of disease, or an efficient method for burying migrants or others within hospitals who had no family to organise or pay for an individual burial.

Approximately 15% of graves at St Mary Spital, London, were described by Connell *et al*. (2012: 13) as “vertical stacks” or “horizontal group” burials, containing between two and 11 individuals, both adults and non-adults. These graves differ in scale from the mass graves associated with the Black Death which contained hundreds of individuals (Cowal *et al*., 2008). However, similar stacked and horizontal graves containing between three and 22 individuals were reported from the medieval Holy Ghost Hospital, Lubeck (Germany) (Lütgert, 2000). The hospital was founded in A.D. 1226 to accommodate 100-200 inmates (*ibid*.), a comparable size to St Mary Spital, London. The burials at Lubeck are believed to relate to the famines and plagues of the 14th century (*ibid*.). Similarly, Gilchrist and Sloane (2005) suggest the burials at St Mary Spital, London, were of individuals, possibly hospital inmates, who died in close succession due to a localised infectious outbreak.

Such a scenario may also be applicable to multiple burials at other hospital sites. For example, a number of double burials were recorded at St Nicholas, Lewes, which, Barber and Sibun (2010) suggest were used to bury multiple individuals following an outbreak of disease. The same motive was suggested by Cessford (2015) for a multiple burial of an adult male, an adult female, an older juvenile, and an adolescent at St John’s, Cambridge. These individuals were buried on the fringe of the cemetery in what Cessford (2015) interpreted as a pit carefully constructed for light industrial use. Three individuals were prone and only the adult female was orientated west-east, suggestive of a rushed burial in a convenient pre-existing location. The multiple burials at St Mary Spital, are different to this one, as the graves there were dug, and the people buried in the same manner and with the same level of care as individual burials. This may indicate a greater level of preparedness by the hospital authorities in larger towns such as London and Lubeck, to manage outbreaks of disease. Due to the high density of the population and general living conditions, deaths caused by infectious disease possibly occurred more frequently, and the larger hospitals may have become more accustomed to managing the burial of multiple individuals in a short time period.

The majority of multiple burials identified in this current research, contained two individuals (n = 8, 53%), six graves contained three individuals (40%), and a single burial held four persons (see Chapter 5, Table 5.8.5). Two graves consisted solely of non-adults, possibly siblings or non-adults from the same community who died concurrently (Dawson, 2017). Their co-burial may have been financially prudent or provided comfort to the living (Gilchrist and Sloane, 2005; Dawson, 2017). One of these burials, of a neonate and an infant, was from St James and St Mary Magdalene, Chichester, when it was an almshouse where, as aforementioned, families were possibly housed. Although these burials were recorded in the same archaeological context, whether they were concurrent, or consecutive was not established. However, if they were concurrent, the joint burial of two infants may have provided solace for the families. This suggestion is potentially supported by the double burials of juveniles, identified at the monastic site of St Peter and St Paul, Taunton (Dawson, 2014). In two of the three double burials recorded here, the bones of the hands were entwined, leading to a suggestion by the excavators that the juveniles were buried with their hands placed together (*ibid*.).

The remaining 13 multiple burials at hospital sites, were comprised of both adults and non-adults. Gilchrist (2012) questions whether an adult interred with an infant provided protection for the infant during their passage through purgatory. Conversely, infants may have benefitted adults who accompanied them through the afterlife: infants who died were regarded as ‘Holy Innocents’ and were believed to be amongst the first to be saved at Doomsday (Gilchrist, 2012). These groupings may represent family burials, as suggested by excavators at two sites, St Bartholomew, Newbury (Clough and Witkin, 2006), and St Nicholas, Lewes (Barber and Sibun, 2010). Without aDNA analysis, the establishment of blood relations is not possible, although these individuals may have had important relationships without necessarily being biologically related. Clough and Witkin (2006) suggested a familial connection may be applicable for the successive stacked burial of three individuals, an older juvenile, a young adult female, and a mature adult female, at St Bartholomew, Newbury. The juvenile and mature female were buried in coffins, and whilst the time lapse between burials is unknown (although indicated by the truncation of the earlier burial), the careful repeated use of the grave indicates that it was marked, and a relationship existed between the individuals (Clough and Witkin, 2006). Wills reveal requests for family members to be buried in close proximity to each other, although these are typically in relation to wealthier families (Daniell, 1997). The group at St Bartholomew may have been hospital inmates, although feasibly, the family were patrons of the hospital who wished to be buried together within the hospital cemetery. Alternatively, this practice may be more prosaically related to the cemetery management and use of available space. However, superimposed burials, such as this, with deliberate secondary interments, are rare in the archaeological record. Gilchrist and Sloane's (2005) study of monastic cemeteries identified 40 burials of this kind involving two individuals, and only two instances where three individuals had been buried within the same grave plot. These burials include combinations of just adults or non-adults, and non-adults with male or female adults. Gilchrist and Sloane (2005: 158) suggest this practice illustrates "an emerging desire to be buried with a loved one". The rarity of this type of burial does not therefore suggest a system of cemetery management but indicates a special form of deliberate burial practice. A second example of a potential familial burial is that of a chalk-cut grave containing an adult male into which an infant was later buried at St Nicholas, Lewes (Barber and Sibun, 2010). The deliberate re-use of the grave again suggests that the existing grave of the adult was visible or marked and purposefully chosen for the burial of the infant (*ibid*.).

A multiple burial from St Margaret's, Gloucester, contained an adult male, an adult female, and an adolescent who was placed in-between the two adults (Evans, 2006). This burial was interpreted by the excavator as a possible familial group, who died in close succession (*ibid*.). However, unlike the burials discussed previously, this burial did not conform to the usual Christian practices as the adult male was inverted, with the head at the east end. The reasons for this practice are unclear, although differences in local practices, accidental misplacement of the body, and punishment and penance, are possible explanations (Gilchrist and Sloane, 2005). Inverted or reversed burials, when they do occur, are more commonly identified with single inhumations. The only comparable multiple burial is of an adult male and a non-adult who were both buried in a reversed position at Whithorn Cathedral Priory, Dumfries and Galloway (Scotland) (Cardy, 1997). A further four non-adults, including two older juveniles and one younger juvenile, were also buried in a reversed position at this site, although in individual burials (*ibid*.). A single reversed burial of an adolescent was observed at the hospital of St John's, Lutterworth (Priest and Chapman, 2002). Here, the excavators concluded the placement was a mistake, stating the use of a shroud potentially caused an error in distinguishing the head and feet (*ibid*.). The same argument was also put forward by Rodwell (2001) for the reversed orientation of an adolescent burial at Wells Cathedral, Somerset. Prone burials were also identified within the hospital cemeteries and are associated with the unbaptised (Gilchrist and Sloane, 2005). Although, accidental placement also appears to be the cause of a prone burial at St Mary Spital, London, as only one of the 71 perinates and four neonates from this site, was buried in a prone position (Thomas *et al*., 1997).

Cardy (1997) proposed the unorthodox positioning of bodies may have been accidental or conceivably deliberate, if for example these individuals had committed suicide (*ibid*.). Incident rates of suicide from the medieval period are unknown, although a modern-day study from the United Kingdom, found that juveniles (categorised as 10-14 years old) very rarely commit suicide, and the intentions of those under 10 years of age are difficult to establish (Windfuhr *et al*., 2008). Furthermore, people who committed suicide were prohibited from burial in consecrated ground, although there were exceptions, for example, if the person was deemed to be insane at the time of death (Daniell, 1997). The Church and common law did not hold children responsible for their actions until 12 years of age or puberty, as such there was no requirement for them to confess (Orme, 2001). Therefore, it is unlikely that inversed burials of juveniles were a form of punishment. Thus, it would appear more likely, that the positioning of these non-adults was due to an error in placement during the burial process.

6.4.5 Individual Burials with Anomalies

An unconventional non-adult burial from the hospital of St Mary Spital, London, was that of a 12-year-old who was buried supine but with their skull placed where the feet, which were missing, should have been. The individual was buried in a simple, individual grave, and no evidence of pathology or trauma were observed by the osteologist on the skeleton, which could have indicated a possible reason for the placement (Thomas *et al*., 1997). Thomas *et al*. (1997) suggest the individual may have died elsewhere and was buried after decomposition had started. This could explain why the head was separated from the body prior to burial, although it does not justify why the skull was placed by the feet. Holder (2019) proposes that the head may have been deliberately placed by the legs, in a practice related to the medieval belief in malevolent revenants. Across medieval north-western Europe, revenants were believed to be evil people or those who died a ‘bad death’, whose soul could re-enter the body or were demonically possessed and returned from the dead to harm the living (Caciola, 1996; Gilchrist and Sloane, 2005). Decapitation and the placement of the head by the knees or feet has been associated with execution cemeteries in early medieval England (Reynolds, 2009; Buckberry, 2014). This practice may have influenced stories of the ‘living corpse’ in Icelandic sagas, and in scholastic and ecclesiastical writings from the early 12th century (Caciola, 1996). However, the archaeological evidence for this burial practice is limited in the later medieval period (Gilchrist and Sloane, 2005). Two other examples are of adult burials: in the 12th century cemetery at St Mary Spital, the head of an adult female was removed from the body, placed upside down, and faced west instead of east (Holder, 2019). One other example comes from the Dominican Friary, Guildford, where the cranium of a young adult male was placed between the knees (Poulton and Woods, 1984). The excavators proposed that this placement had occurred due to the truncation of the body during the creation of a modern soakaway, although, Gilchrist and Sloane (2005) suggest this example may have been a deliberate act, related to belief in revenants. If the placement of bodies was deliberate, these examples suggest that a non-adult was considered as much of a threat in the afterlife as an adult and treated accordingly in the same manner.

One further anomalous burial is that of an older juvenile from St Peter’s, Bury St Edmunds, who exhibited indicators of Klippel-Feil Syndrome (Anderson, 2012). This individual had unhealed cut marks on the thoracic spine, rib bones were missing, and as there was no evidence the grave was disturbed after the burial, Anderson (2012) suggests this indicates a deliberate perimortem act of cutting the rib cage with a knife or blade. A large stone was placed in the rib cage, where the heart would have been during life. Klippel-Feil syndrome is characterised by congenital defects of the cervical spine, resulting in a short neck, low posterior hairline, and restricted movement of the neck (Tracy *et al*., 2004). Associated abnormalities can include scoliosis, rib abnormalities, deafness, chronic headaches, and neurological deficits (Tracy *et al*., 2004; Nouri *et al*., 2019). This condition is relatively rare and today one case is identified in every 30,000-40,000 live births (Lewis, 2018). Anderson (2012) suggests that if the juvenile from St Peter’s had mental health problems caused by the syndrome, they may have been viewed as dangerous, and the nature of the burial may again reflect the medieval belief in revenants. Alternatively, the intentional opening of the chest cavity could indicate some form of autopsy, or the deliberate removal of the heart (Anderson, 2012). The extraction of the heart shortly after death was practiced across medieval Europe, particularly during the time of the Crusades, although it was typically reserved for royalty, noblemen, and ecclesiastics who died away from home (Daniell, 1997). It was believed the heart held the essence of a person and could be returned to be buried in a holy place where the family could pray for salvation (Mafart *et al*. 2004). This seems an unlikely scenario for a non-adult buried within a leprosarium, and it is more likely that the heart was removed for a medical or superstitious reason (Anderson, 2012).

This chapter has discussed the results of the analyses on the demography and health status of non-adults from medieval hospital sites. The discussion was situated within the three themes of this thesis, exploring the familial, socio-economic, and environmental influences on non-adult health, the charitable assistance non-adults potentially received from hospitals, and the burial practices employed by these institutions for non-adults who died within their care. The following, and final chapter of this thesis will draw on the discussion presented here and summarise how the findings of this research have advanced our understanding of the lives and deaths of non-adults in medieval hospitals. Suggestions for future research will be made, regarding further comparisons with parish and monastic sites, and scientific analyses of the skeletal remains from hospital sites.

Chapter 7. Conclusion

The primary aim of this research was to explore the lives and deaths of non-adults buried at English medieval hospital sites, through an examination of the archaeological and osteological record. A total of 27 sites were identified from which the skeletal remains of 1,506 non-adults were reported. The health status of these individuals was explored through statistical analyses of data from osteological reports. In conjunction with archaeological burial evidence, their treatment in death was considered. Findings were interpreted within the medieval historical context and through non-statistical comparisons with contemporary parish and monastic cemetery populations. This afforded a fuller investigation of the social, economic, and health reasons for non-adults entering hospitals. Modern-day clinical studies on disease and social practices were additionally employed to aid the exploration of the lived experiences of non-adults with certain pathologies and trauma, and the potential care and treatment of these conditions within medieval hospitals.

7.1 Summary of Findings

With the exceptions of orphans and scholars, non-adults were previously thought to be scarce in medieval hospitals (Orme and Webster, 1995). This current research has demonstrated the variability of hospital populations, and whilst non-adults were absent at 13 of the sites considered in this thesis, they were present at 27 hospitals. Non-adults were in hospitals for various reasons: some urban hospitals raised orphaned and abandoned younger juveniles, whilst older juveniles and adolescents were potentially staff members or students, although many likely entered hospitals due to acute or chronic illness. Younger juveniles were identified in greater proportions and more consistently at leprosaria and almshouses. These institutions provided longer-term housing and conceivably accommodated more families. Inter-generational poverty and illness were factors which feasibly created a higher risk of mortality for infants in these settings. Conversely, the differing proportions of younger juveniles at general hospitals may be explained by their specific admission policies: pregnant women and abandoned children were refused entry at some hospitals, whilst others were funded specifically to provide care for these groups.

Older juveniles were undoubtedly inmates of hospitals although some were possibly staff members or bound to monastic orders. This may account for the presence of this age group in relatively consistent proportions in hospitals, regardless of type or location. Higher proportions of adolescents were identified at urban general hospitals compared with leprosaria, almshouses, and parish cemeteries. Urban centres attracted adolescents migrating for work or undertaking pilgrimage. Yet, if work was not secured, and without familial support, adolescents could find themselves in dire poverty. Which, coupled with the risks of exposure to new strains of disease, could explain the elevated risk of mortality for adolescents who entered urban hospitals.

7.1.1 Social, Economic, and Environmental Impacts on Health

The first theme explored in this thesis was the impact of socio-economic and environmental factors on the health and well-being of non-adults. Congenital conditions were identified in a greater proportion of non-adults from hospital populations, than contemporary parish and monastic cemetery populations. Modern-day studies indicate that children born into poverty are more likely to acquire congenital conditions (Pawluk *et al*., 2014; Matin *et al*., 2020). Boswell (1988) suggests physical deformity or childhood illness, coupled with parental poverty, were reasons for child abandonment during the medieval period. This evidence suggests that it was not necessarily the congenital condition *per se*, but potentially the hardships faced by some mothers in poverty, which resulted in the placement of a child into hospital supervision.

Poverty is further associated with a greater risk of childhood malnutrition. This is a probable reason for the elevated levels of cribra orbitalia and dental enamel hypoplasia (DEH) identified in hospital non-adult populations. Indicators of malnutrition were identified in a greater proportion of adolescents, a possible example of the osteological paradox, as younger juveniles who experienced malnutrition may have died before skeletal markers could manifest (Wood *et al*., 1992). Evidence of malnutrition was notably higher at St Mary Spital, London, than other hospital sites, and possibly suggests the different status of St Mary Spital compared with other hospitals considered in this thesis, as one of the largest hospitals in medieval England, located in the dense urban city of London. It is likely that adolescents from this hospital, who survived environmental stressors and malnutrition during juvenescence, were vulnerable to illness and succumbed to disease after migrating to the capital city. Rates of dental disease were also higher in the St Mary Spital non-adults than other hospital and non-hospital populations, suggesting non-adults from St Mary Spital consumed a poorer quality diet which promoted dental disease.

It was established that environmental conditions existed in rural and urban environments which facilitated the development and spread of diseases such as sinusitis and tuberculosis (TB). Hospital inmates potentially originated from both rural and urban centres, although from the available secondary osteological data, it is not currently possible to discern the origins of inmates. Rates of infectious disease were greater in non-adults from marginal sites which could reflect the differing functions of hospitals: typically, leprosaria and almshouses accommodated individuals with chronic diseases, whilst general hospitals provided shorter-term care for those with acute infections which usually leave no skeletal markers.

Adolescents from hospital sites exhibited a higher rate of joint disease and fractures than other adolescents from contemporary parish and monastic sites. Certain workplace roles in urban and rural areas, particularly those of lower status, were physically demanding, placing repetitive strain on joints and increasing the risk of sustaining trauma. Modern-day studies suggest that within agricultural communities, non-adults undertake work that contributes to joint strain and micro-trauma from a young age (Milella *et al*., 2015). The continuation of work in agriculture and other industries further increased the risks of accidental injury during adolescence. Inter-personal violence was another possible cause of trauma, attested to in documentary accounts of violence between young men in poorer urban areas (Hanawalt, 1993). The overall findings of this study relating to trauma, indicate that non-adults from hospital sites were from low socio-economic backgrounds and started physically strenuous work at an earlier age than their peers, placing them at a greater risk of acquiring joint disease or sustaining an injury.

The above strands of enquiry were drawn together to explore the complexities of multi-factorial influences on health and the co-occurrence of pathologies and trauma. Within the hospital population, non-adults with one stress indicator were more likely to exhibit another. An association was identified between general stress indicators and certain pathologies, namely, TB, joint disease, endocranial lesions, and dental disease. The cyclical and inter-generational nature of poverty, malnutrition, disease, and physical stress is evidenced in modern-day studies (Ayenigbara, 2013; Adebisi *et al*., 2019; Wells *et al.*, 2020; Dittmar *et al*. 2021). From the data in this current study, it can be inferred that due to familial and socio-economic factors, many non-adults from medieval hospital sites experienced poverty, malnutrition, and environmental stress, leaving them vulnerable to an increased severity of infection. The data suggest that younger juveniles, without fully developed immune systems, were particularly vulnerable to mortality from acute infections, whilst chronic illness or fragility could prevent adolescents from working, worsening their poverty, and increasing their risk of early mortality.

7.1.2 The Role of the Medieval Hospital

The second theme explored in this thesis, was the role of the medieval hospital in providing care for non-adults. This was achieved through the adaptation of Tilley's (2015) 'Bioarchaeology of Care' model, and the use of modern-day clinical studies to understand the progress of particular diseases. Many non-adults did not exhibit indicators of disease or trauma, and probably died from acute infections. For these individuals, in accordance with the Seven Acts of Mercy, hospitals provided relatively clean and warm accommodation, a sufficient diet, clean water, and the attention of hospital staff, which would have eased the distress of illness. In addition to palliative care, and importantly within the spiritual environment of a hospital, religious succour could be found which prepared inmates for a 'good death'.

The skeletal evidence recorded in osteology reports of disease and trauma exhibited by non-adults, suggests that some required longer-term and more specialised care. Diseases, such as TB, leprosy, and syphilis, could result in severe infirmity and disability, and a reliance on others for survival. Archaeological excavations and historical documentation show that hospital staff had knowledge of medicinal herbal preparations, and hospitals had their own herb gardens (Moffat, 1988; Meaney, 2000; Harward *et al*., 2019). Combined with trace evidence of metals used in medieval treatments, it is likely that medicinal preparations were administered to inmates for a range of illnesses. More skilled treatments, for example, bloodletting, cauterisation, or mercurial therapies, were possibly used within hospitals in the treatment of non-adults in the advanced stages of disease. As discussed in Chapter 6, the 'healed' status of most fractures identified on non-adult remains does not necessarily indicate specialised medical knowledge existed in medieval hospitals, yet, it is possible hospital staff did have the knowledge to stabilise fractures and hospitals were able to provide general care to non-adults enabling them to recover. Some fractures were possibly treated prior to hospital admission, although non-adults without family support who sustained injuries, may have relied on hospital's charity for the duration of their recovery.

7.1.3 Burial Practices

The final theme examined was the burial practices employed by hospitals. It was established that most non-adults identified within hospital sites were interred within hospital cemeteries as opposed to buildings or other structures, in accordance with standard medieval burial practices, and with the same care afforded to adults. Differences in burial practices were identified, particularly in relation to younger juveniles. Zoning of younger juvenile burials was potentially identified at three sites where infants were possibly buried in preferential areas in the belief they gained protection through purgatory, or alternatively, in areas left un-consecrated to allow the burial of the unbaptised. Furthermore, coffins were used more frequently for the burial of younger juveniles. This may reflect local burial customs, and the belief that younger children required physical and spiritual protection in death. Protecting the living and beliefs in revenants possibly explain the employment of unconventional burial practices for a small number of non-adults. The few inverted burials probably resulted from accidental placement of the body within the grave. Yet, the apparently deliberate misplacement of a skull in one instance, and indicators that the heart of another non-adult was removed, suggest that non-adults deemed to be ‘evil’ were, like certain adults, considered a threat after death, and hence, the same localised practices and precautions in burial were taken.

Multiple burials were identified which may have comprised familial members or individuals who died in close succession. Whilst not common in medieval England, similar multiple burials have been recorded at contemporary parish and monastic cemetery sites. Larger multiple burials, containing up to 11 adults and non-adults were found at St Mary Spital, London, and comparable sized graves were identified at a medieval hospital in Germany. These larger graves within hospital sites are smaller than the mass graves uncovered at dedicated plague cemeteries and potentially represent the burial of inmates who died due to localised outbreaks of disease. Alternatively, they may demonstrate that urban hospitals were able to manage the simultaneous burial of multiple individuals, and consequently, hospital resources were utilised by town officials during widespread outbreaks of plague or famine.

7.2 Study Limitations

As acknowledged in Chapters 3 and 4, within any study of past populations, bias will occur for multiple reasons. Archaeological material objects or skeletal remains are often acquired through limited and targeted archaeological excavations and historical documentation was typically created for specific, often legal, or financial, purposes. Consequently, the entire population of the place or period being researched cannot be studied in its entirety. In the current research, the combined use of archaeological, secondary osteological data, and historical evidence, helps to mitigate bias, although it does not remove it. The excavations of medieval hospital sites uncovered a random sample of the cemetery population, which can therefore, arguably, be considered representative, although the zoning of burials by age at some sites can result in a distorted impression of the cemetery demography.

A sufficient sample size of non-adults was acquired for this current research to undertake certain statistical analyses, although as stated in Chapter 4, not all questions asked of the data could be statistically answered due to the small sample size of particular age or pathology categories. Most demographic analyses were conducted using three age categories: younger juvenile, older juvenile, and adolescent. There was seldom adequate data to permit statistical analyses of perinate, neonate, infant, and child age groups. Whilst descriptive observations of the data were made, future excavations of hospital sites may make such analyses possible, enhancing our understanding of socio-economic factors and the development of disease and stress indicators for this younger age group. This would be of further interest as medieval burial practices in parish cemeteries, particularly the practice of zoning, appears to differentiate younger juveniles, notably those around two years of age (Gilchrist, 2012).

7.3 Concluding Remarks

Medieval hospitals were diverse institutions, of varying size and differing financial means, which often housed, or excluded, specific categories of people. Children were rarely referenced in hospital documents and consequently, their place within these institutions is frequently overlooked. This thesis has sought to highlight the presence of non-adults by drawing together archaeological and osteological data from 27 medieval hospital sites where the skeletal remains of 1,506 non-adults were identified. Through analyses of the osteological data and modern-day clinical studies, it has been established that inter-generational poverty, low socio-economic status, malnutrition, and environment hazards, all contributed to the increased risk of disease and trauma experienced by many of these non-adults. Ultimately, all the non-adults considered in this current research died prematurely, and thus, were not able to adapt and survive in their environments. Yet, archaeological and historical evidence indicates that within the medieval hospital, they were cared for, given a regular diet, and received medicinal treatments. The religious environments of hospitals ensured non-adults the opportunity of a 'good death', and they were afforded proper burials. Whilst there is scope to further the research undertaken here, this study has demonstrated that the consideration of non-adults can enhance our understanding of both the lived experiences of non-adults during the medieval period, and the various roles of the hospital within medieval society, establishing the importance of hospital institutions to both adults and non-adults who relied on its services.

7.4 Future Research

The current research has utilised existing osteological reports to identify medieval hospital non-adult demographics and pathologies. These reports could be explored further to include analyses of the pathologies and trauma identified on adult skeletal remains which were potentially acquired in childhood. Markers of nutritional deficiency or environmental stress which develop during childhood, for example, DEH and cribra orbitalia, reveal in adults, an adaptive response which enabled the individual to survive (Watts, 2015; McFadden and Oxenham, 2020). As discussed in Chapter 3, the identification of childhood disease or trauma on adult remains can be problematic. Although Glencross and Stuart-Macadam (2000) argue that careful consideration of the location and type of trauma can determine if a fracture occurred during childhood. The identification of such trauma in adult skeletal remains would enhance our understanding of the experiences of non-adults in the medieval period. Furthermore, comparisons could be made between non-adults who died prematurely, and those who survived childhood but found themselves reliant on hospitals as adults.

Two hospital sites (Thornton Abbey, Lincolnshire, and St Leonard's, Northumberland) have been excavated in the past decade. Skeletal remains from these sites were osteologically analysed, although the data were not available at the time this current study was conducted. The inclusion of these data in future analyses would advance our knowledge of non-adults at hospital sites, as the use of up-to-date methods of osteological analysis will provide more accurate and reliable observations and detailed data on the skeletal remains. Non-statistical comparisons were made between hospital populations and contemporary parish and monastic cemetery populations in Chapter 5. However statistical analyses were not conducted due to the time needed to collate and prepare data for statistical analysis. Such analyses would be beneficial and could more fully explore differences in the health status, and socio-economic backgrounds of non-adults buried within these differing settings. This would provide a more nuanced picture of non-adult hospital inmates, placing them more firmly within their social context.

Other avenues of investigation which would be beneficial include stable isotope analysis. Analysis of nitrogen and carbon stable isotopes can indicate dietary intake, which can be used to infer economic and social status (Müldner, 2009). Differences in the diets of for example, non-adults and adults, or non-adults from hospital sites and those from other contemporary sites, could be indicative of differing social status and access to certain foods. Strontium and oxygen isotopes could also be used to identify migrants within the hospital cemetery populations, as observed in other past populations who migrated within Britain (Millard *et al*., 2005; Hemer, 2015). Determining the proportion of non-adults who migrated to towns, identifying how far from home and family support they had travelled, or whether lepers entered local leprosaria, would improve our understanding of hospital demographics and the reasons for non-adults entering hospitals (Filipek *et al*., 2022).

The application of aDNA analysis is transforming our understandings of past populations, although its use is limited due to costs (Sykes *et al*., 2019). Within hospital cemetery populations, the technique could determine whether individuals in multiple burials were biologically related (Rott *et al*., 2018). Additionally, identifying members of the same family within a cemetery would expand our understanding of which hospitals housed families, and if this changed through time. The sex of non-adults can be ascertained through aDNA analysis and also through peptide analysis, a cheaper and less destructive method of reliably establishing the sex of non-adult skeletal remains (Stewart *et al*., 2017). Determining the sex of non-adults would facilitate a fuller discussion of the health status of non-adults, permitting the examination of differences in the cultural or family treatment of boys and girls, and risk factors relating to occupations undertaken by females and males (Tierney and Bird, 2014; Stewart *et al*., 2017; Inskip *et al*., 2019). Furthermore, by establishing the sex of non-adults, questions could be asked of hospital admission policies, and whether a bias towards boys or girls existed. Additionally, aDNA analysis can identify the presence of diseases such as plague (DeWitte, 2015), leprosy (Taylor *et al*., 2013), and TB (Dawson-Hobbis *et al*., 2021). Information on the inter-twinning roles of genetics and infectious disease can also be enhanced through aDNA analysis (Brickley *et al*., 2020). Such information would enable the formation of a better understanding of the social networks of non-adults buried at hospital sites and the environmental hazards they faced. However, isotope and aDNA analysis are destructive analytical methods, and thus, need to be used with consideration and the information obtained from them balanced against ethical considerations of sampling human remains (Larsen and Walker, 2005; Squires *et al*., 2020).

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Appendix 1: Medieval Hospital Site Summaries

The information in the site summaries was compiled from individual site reports, Knowles and Hadcock's (1953) *Medieval Religious Houses*, and British History Online (www.british-history.ac.uk).

Site 1. St Bartholomew, Bristol, Avon.

Hospital Type: General hospital, Augustinian Rule.

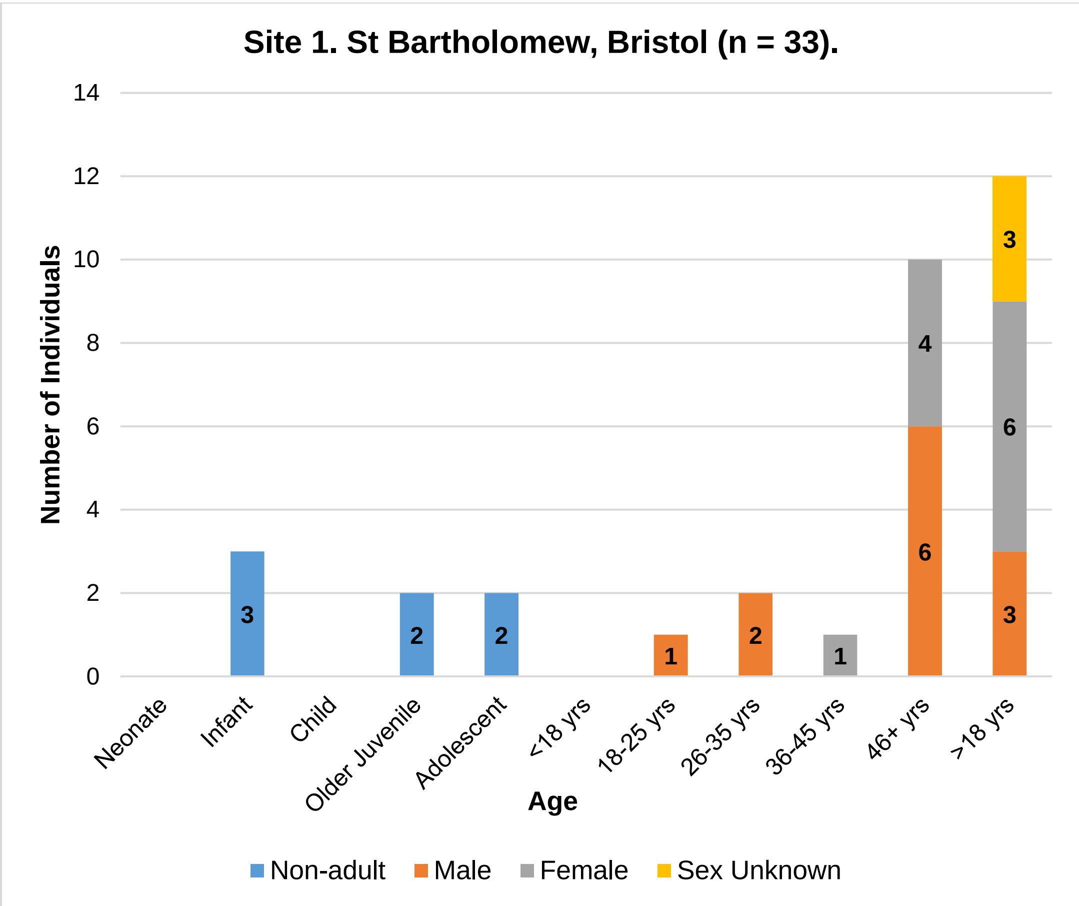
Founded: c.1234.

Dissolved: 1531 (converted to Bristol Grammar School 1532).

Date of Cemetery: first recorded in 1340, excavated burials thought to relate to Period 4B (c.1400 - c.1532).

Population: Intramural burials from church building 1B. MNI 44. MNI analysed 33. Adult male: 12. Adult female: 11. Adult sex unknown: 3. Non-adult: 7. High rates of fractures were recorded (7/33, 21.21%).

Reference: Price and Ponsford, 1998.



Site 2. St Bartholomew, Newbury, Berkshire.

Hospital Type: General hospital, Augustinian Rule.

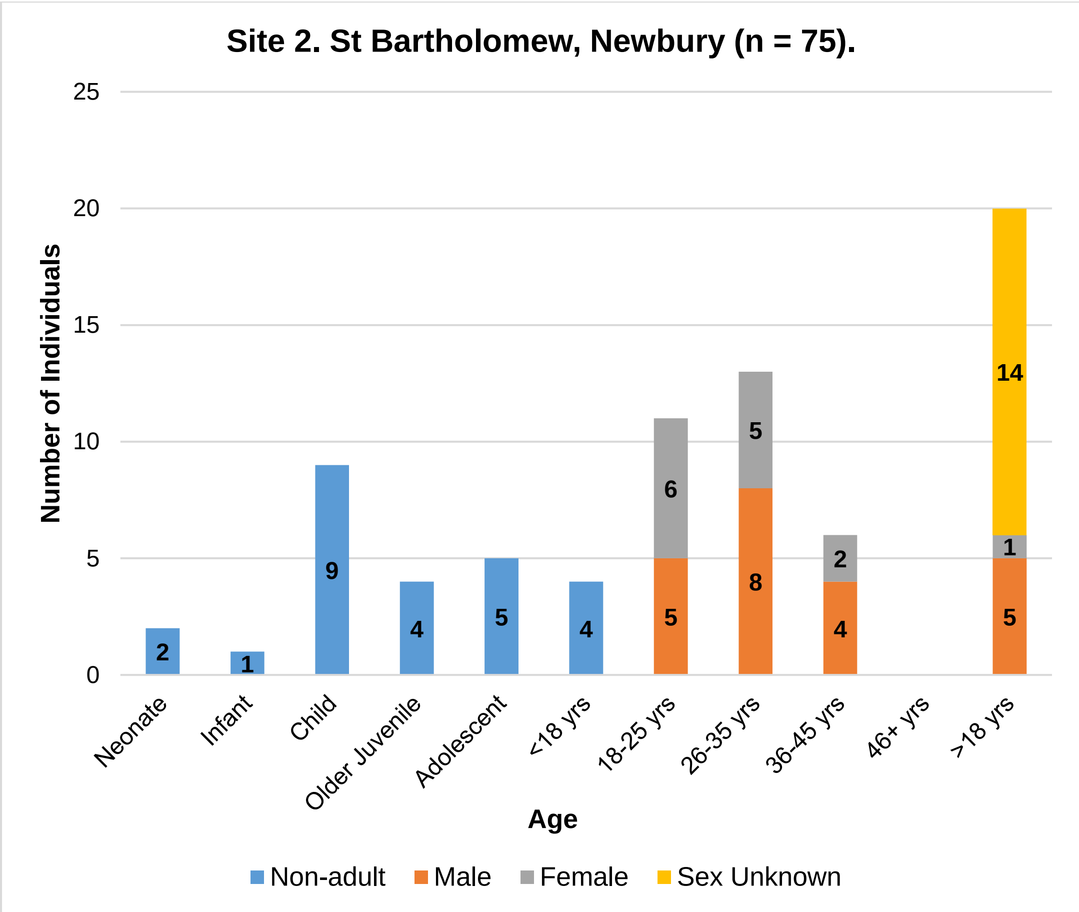
Founded: Pre c.1200 (first documentary reference: 1215).

Dissolved: 1554 (converted to Almshouses).

Date of Cemetery: 1267 (right of burial granted) - 1554.

Population: MNI 75 (56 articulated individuals and 19 disarticulated individuals). Adult male: 22. Adult female: 14. Adult sex unknown: 14. Non-adult: 25. High levels of pathology were identified. A case of congenital syphilis was identified in SK 184, a child 1-1.5 years of age, who would have contracted the disease from its mother whilst in utero. Radiocarbon dating has dated the individual to 1150-1260 cal. A.D., with a 95% probability, pre-dating Columbus's discovery of the New World.

Reference: Clough and Witkin, 2006.



Site 3. St Margaret, High Wycombe, Buckinghamshire.

Hospital Type: Leprosarium for men.

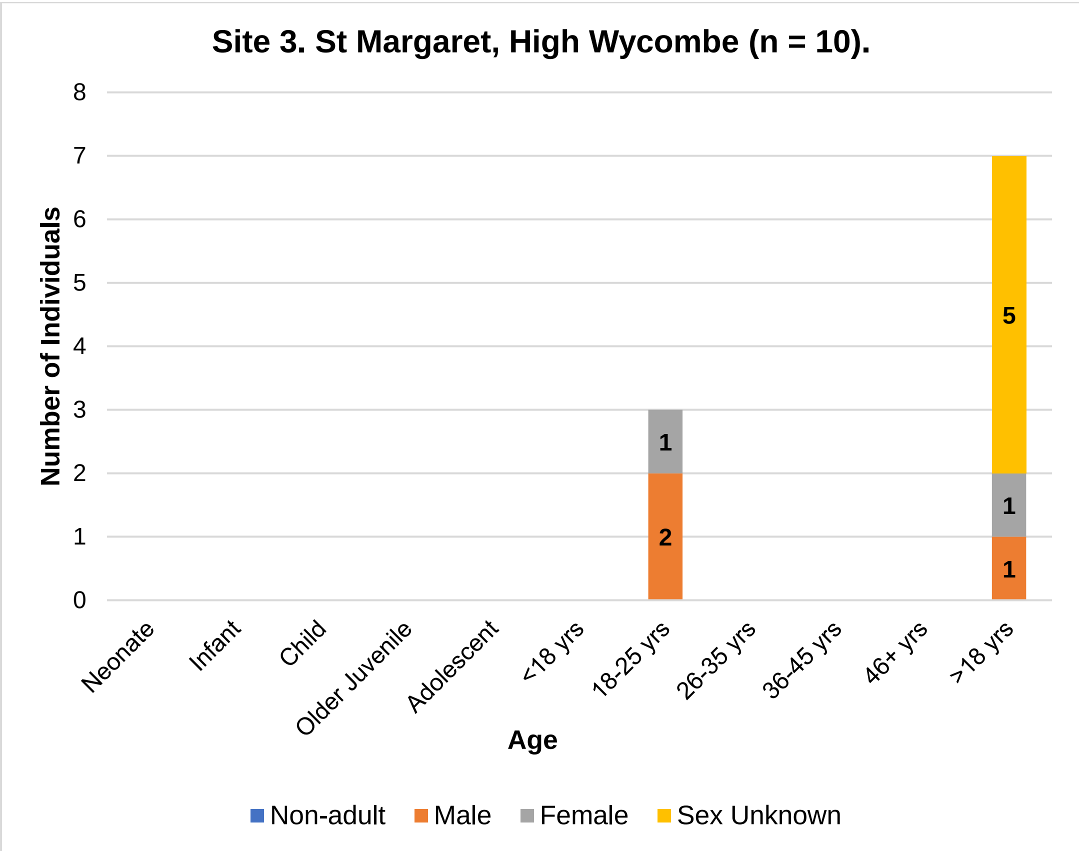
Founded: Pre 1229 (first documentary reference: 1229).

Dissolved: 1599?

Date of Cemetery: c.1229 - 1599?

Population: MNI 12. MNI analysed 10. Adult male: 3. Adult female: 2. Adult sex unknown: 5. Non-adult: 0. 70% (7/10) of the individuals exhibited skeletal changes indicative of leprosy.

Reference: Farley and Manchester, 1989.



Site 4. St John the Evangelist, Cambridge, Cambridgeshire

Hospital Type: General hospital, Augustinian Rule.

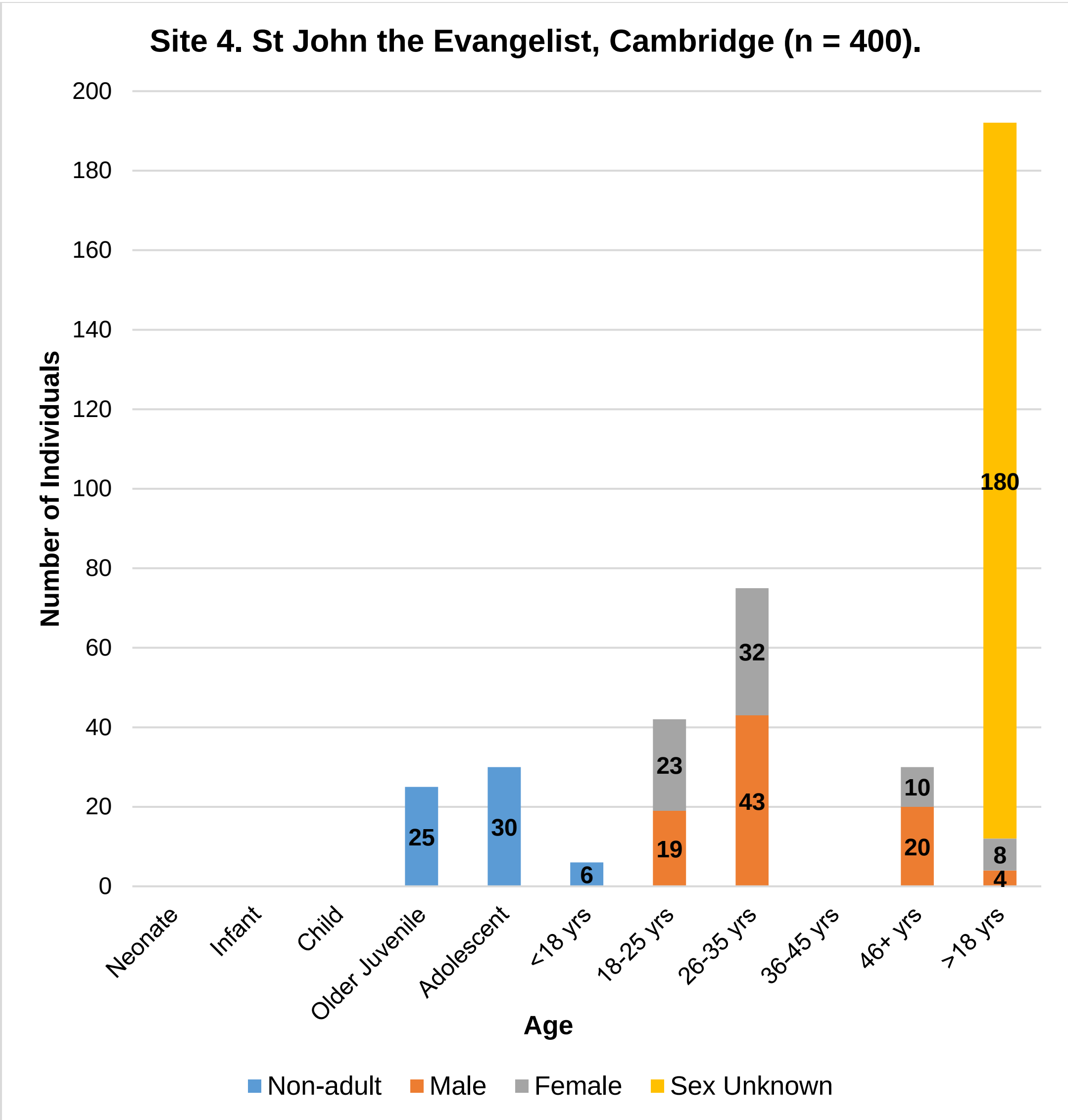
Founded: c.1195 (first documentary reference: 1204).

Dissolved: 1511 (converted to St John's College).

Date of Cemetery: c.1200 - 1511. Three phases of cemetery use were identified: Early c.1200 - 1300, Mid c.1300 - 1400, Late c.1400 - 1511.

Population: MNI 404. MNI analysed 400. 92 individuals were analysed in detail (77 adults, 15 non-adults). Adult male: 86. Adult female: 73. Adult sex unknown: 180. Non-adult: 61. No children under five years of age were identified.

Reference: Cessford, 2012.



Site 5. St Margaret, Huntingdon, Cambridgeshire.

Hospital Type: Leprosarium.

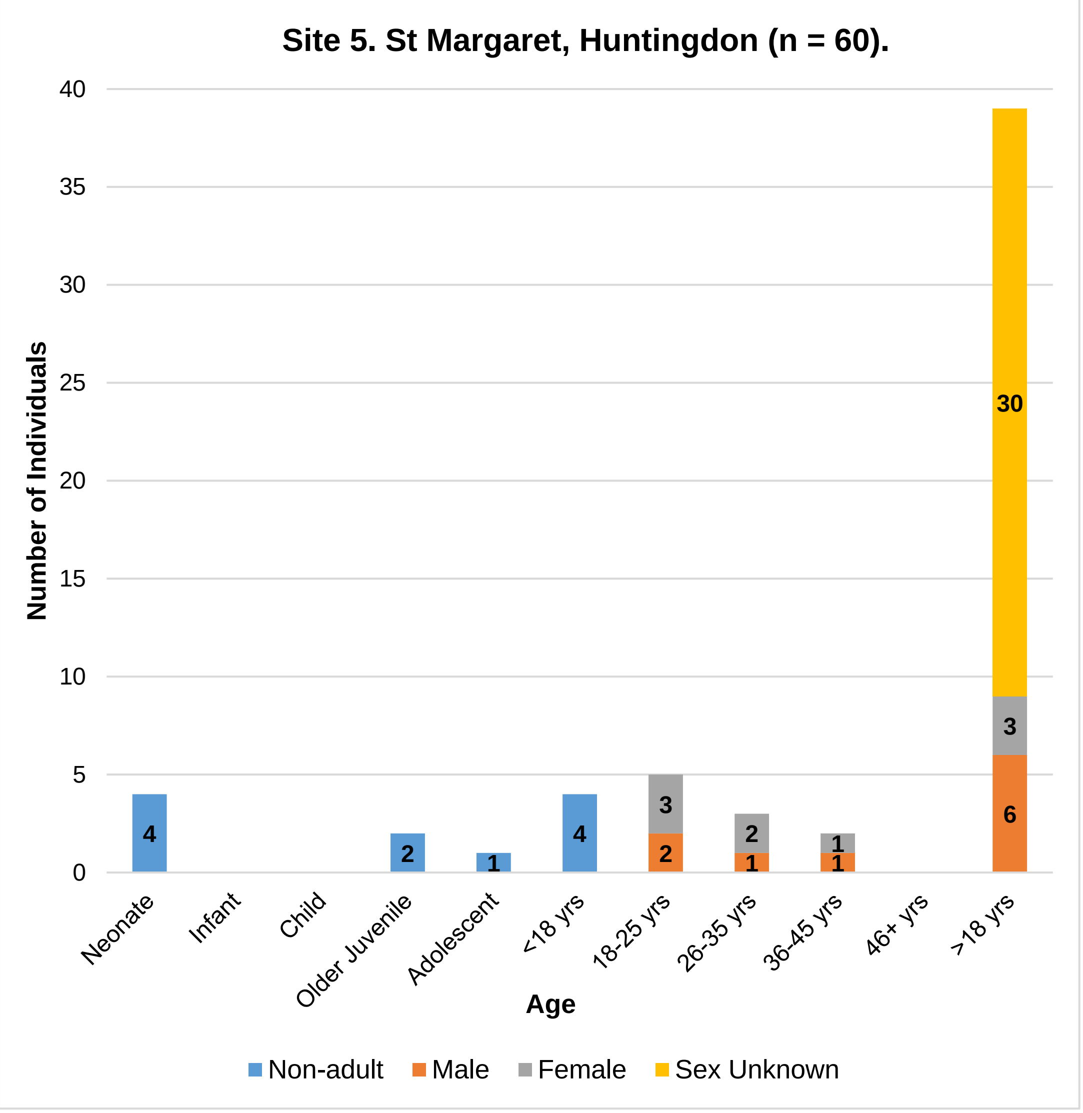
Founded: c.1150 (prior to 1165).

Dissolved: 1341 (granted to Trinity Hall, Cambridge 1461).

Date of Cemetery: Concurrent with the hospital?

Population: MNI 60. Adult male: 10. Adult female: 9. Adult sex unknown: 30. Non-adult: 11. An additional four non-adult individuals were recovered from the spoil and are assumed to be from the cemetery burials. 17 individuals (28%) exhibited skeletal changes indicative of leprosy.

Reference: Mitchell, 1993.



Site 6. St Leonard's, Peterborough, Cambridgeshire.

Hospital Type: Leprosarium and later general hospital, dependent of Peterborough Abbey.

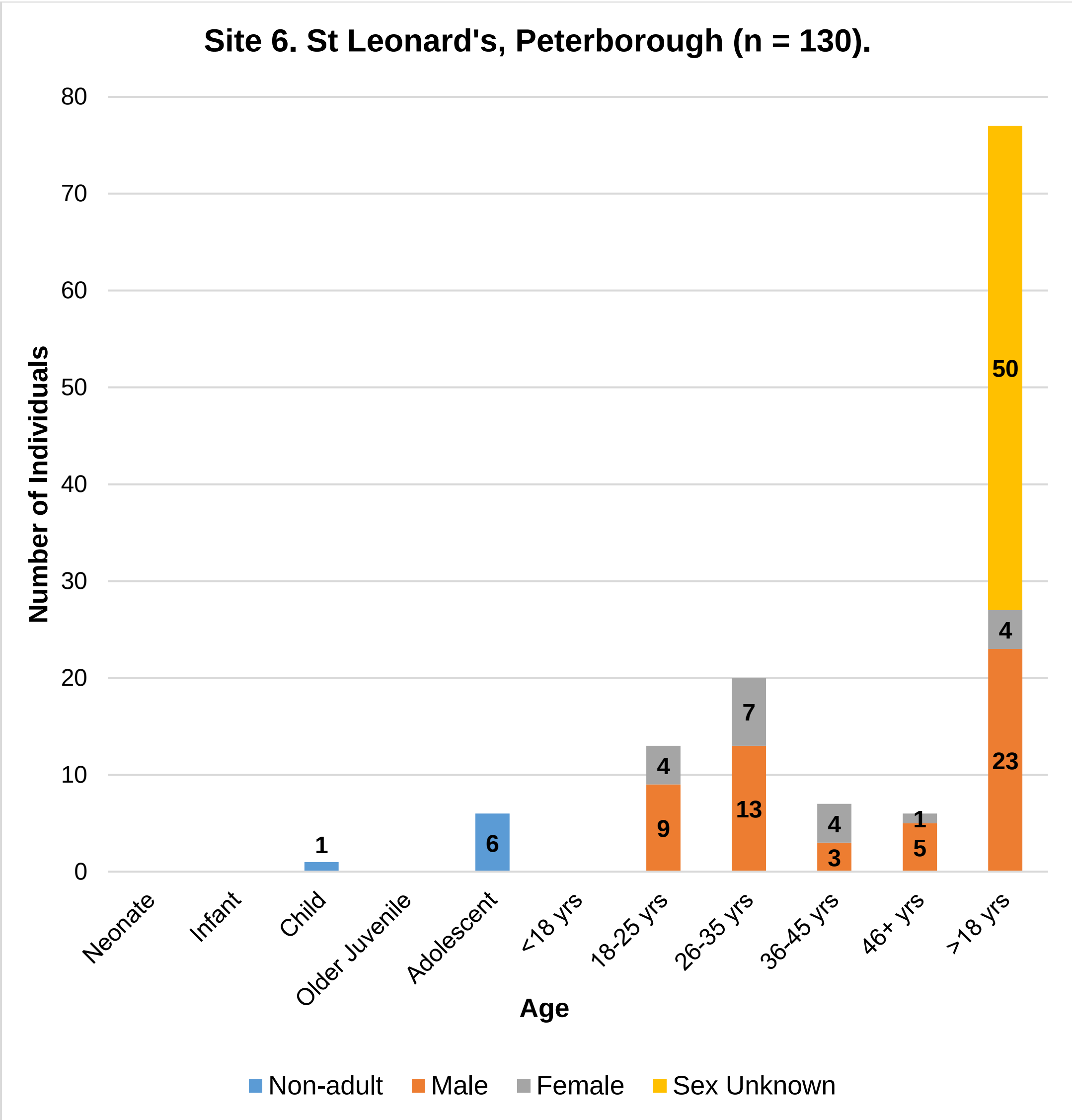
Founded: Pre 1125 (first documentary reference: 1125).

Dissolved: 1535 (possibly converted to a Pest House 1600s).

Date of Cemetery: 12th C. - 1535 (burials possibly continued until 1665). Two phases of cemetery use were identified; 83 skeletons were allocated to Phase 1, a well organised cemetery comprising of nine slightly irregular rows. Phase 2 was a less well organised cemetery consisting of 47 skeletons.

Population: MNI 133. MNI analysed 130. Adult male: 53. Adult female: 20. Adult sex unknown: 50. Non-adult: 7.

Reference: McComish *et al*., 2017.



Site 7. St John the Baptist, Chester, Cheshire.

Hospital Type: General hospital and later almshouse, dependent of Birkenhead Priory (from 1316).

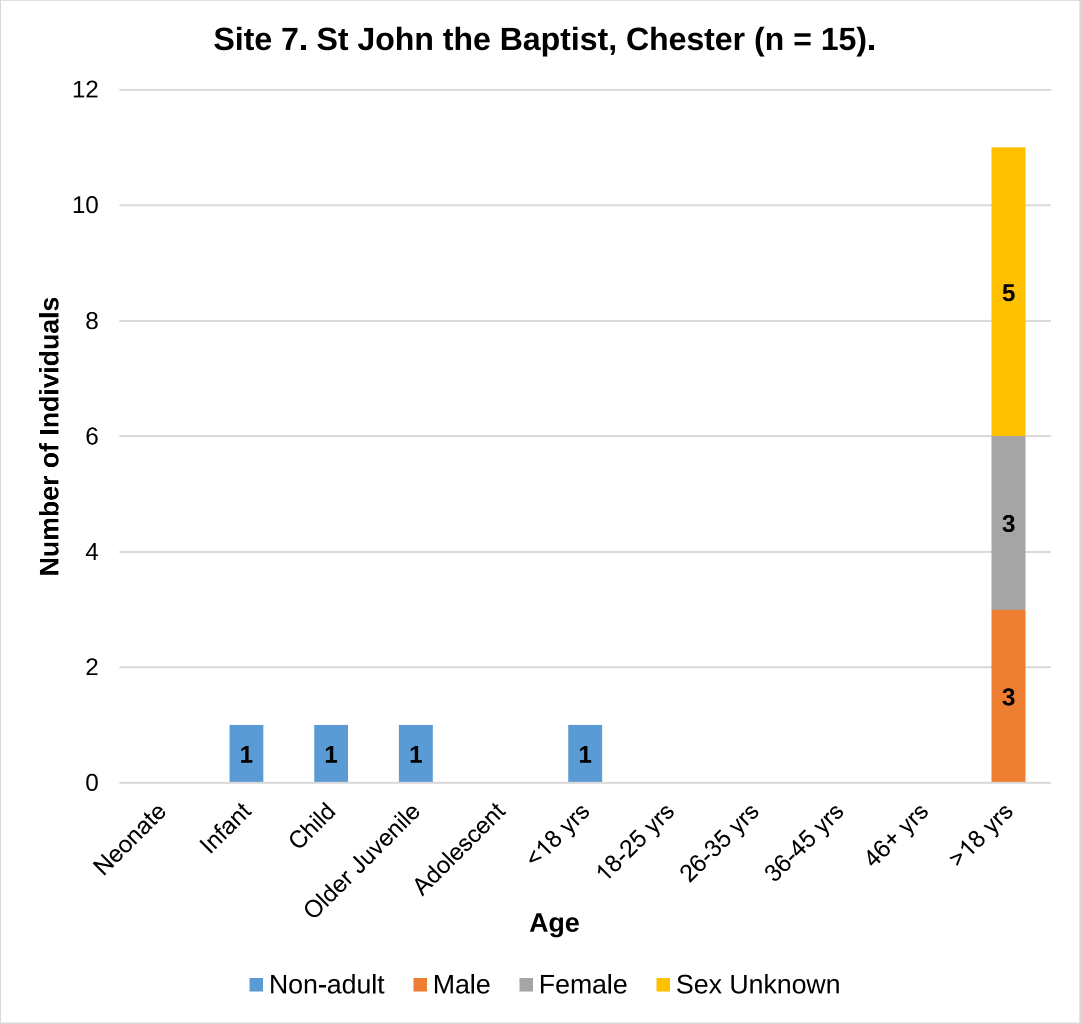
Founded: c.1190.

Dissolved: 1644 (demolished during the English Civil War).

Date of Cemetery: Pre 1200 - c.1644.

Population: MNI 15. Adult male: 3. Adult female: 3. Adult sex unknown: 5. Non-adult: 4. Three *in situ* truncated individuals were identified, a further ten individuals were identified from disarticulated human remains disturbed by 18th and 19th century activity.

References: Poole, 2012; Poole, 2015.



Site 8. St Mary of the Peak, Castleton, Derbyshire.

Hospital Type: General hospital.

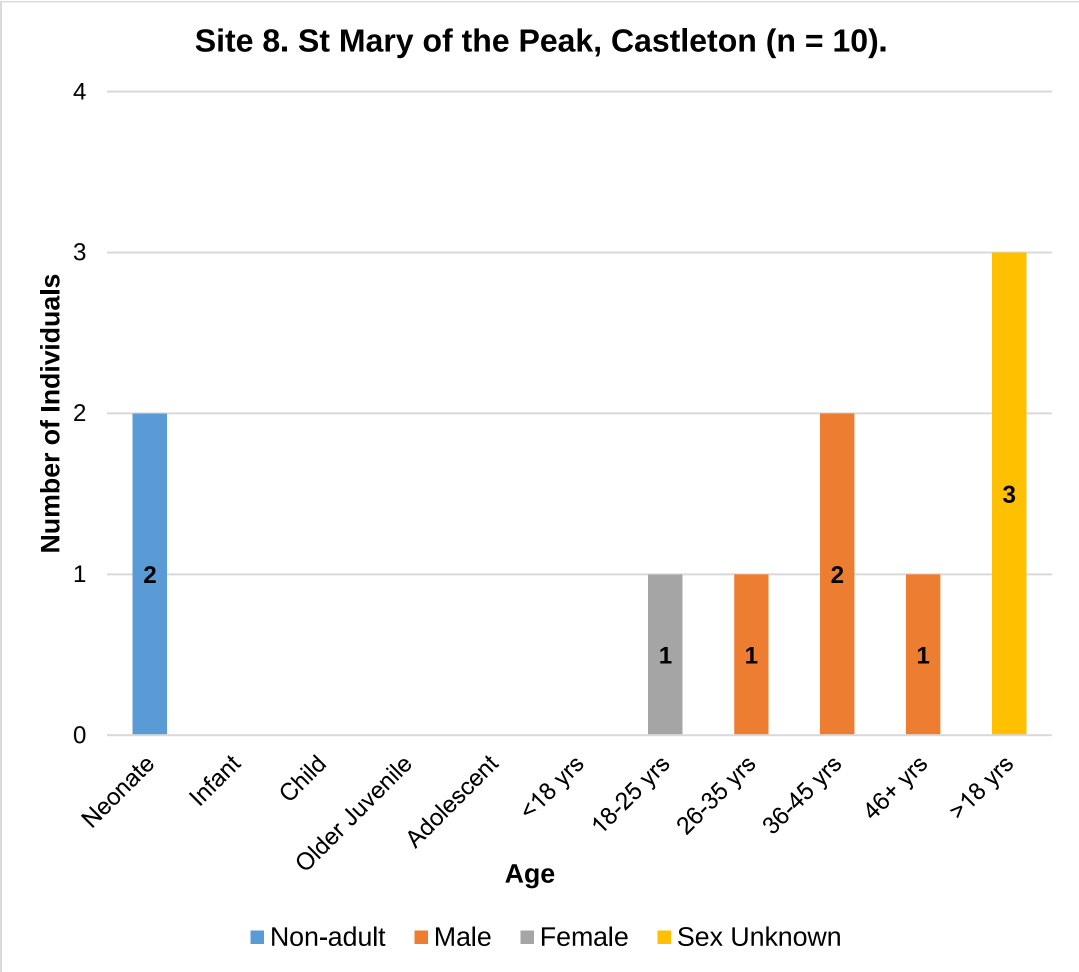
Founded: 12th C.

Dissolved: 1542 (the hospital stopped functioning some time prior to this date).

Date of Cemetery: Concurrent with the hospital?

Population: MNI 10. Adult male: 4. Adult female: 1. Adult sex unknown: 3. Non-adult: 2.

Reference: Bloxham, 2013.



Site 9. St Leonard's, Chesterfield, Derbyshire.

Hospital Type: Leprosarium.

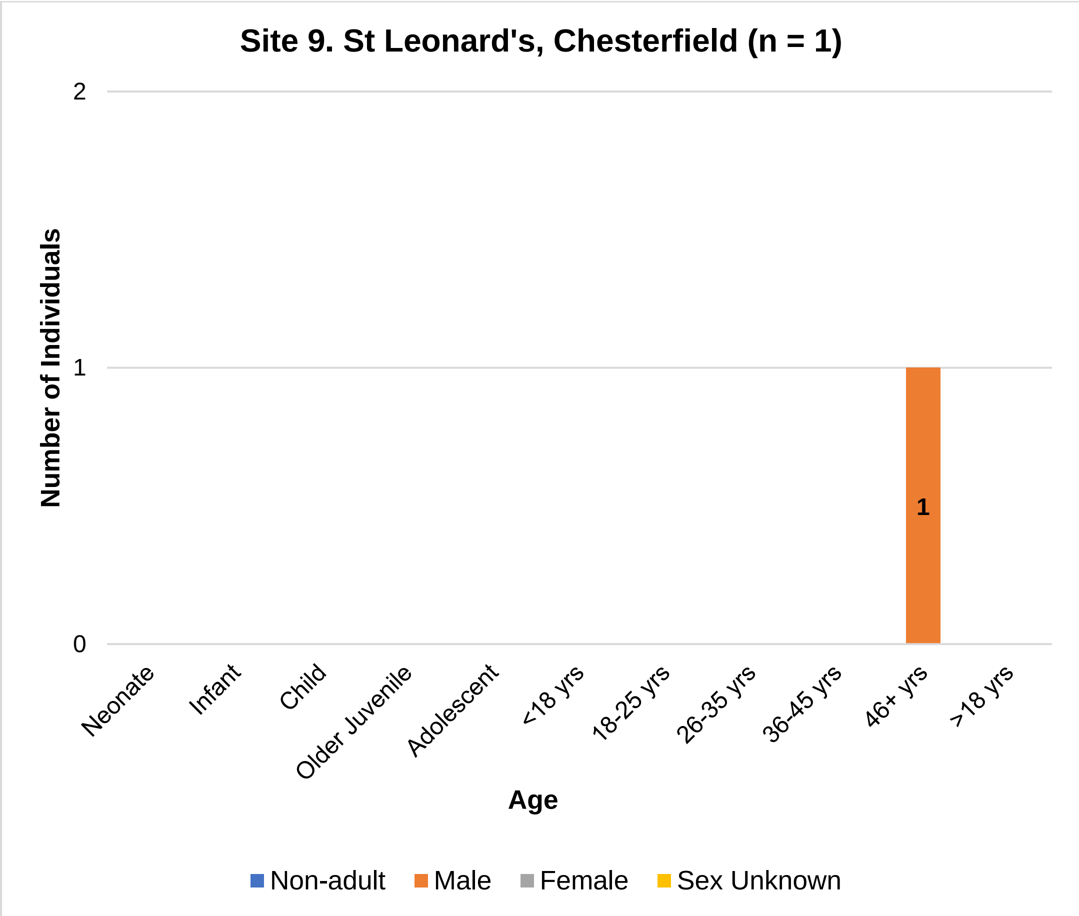
Founded: 1171.

Dissolved: c.1547.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 1. Adult male: 1. A paten and possible chalice were identified on the chest area, suggesting the individual may have been a priest.

Reference: Witkin, 2000.



Site 10. St Nicholas, Lewes, East Sussex.

Hospital Type: General hospital (possibly serving as a leprosarium for a short period), dependent of Lewes Priory.

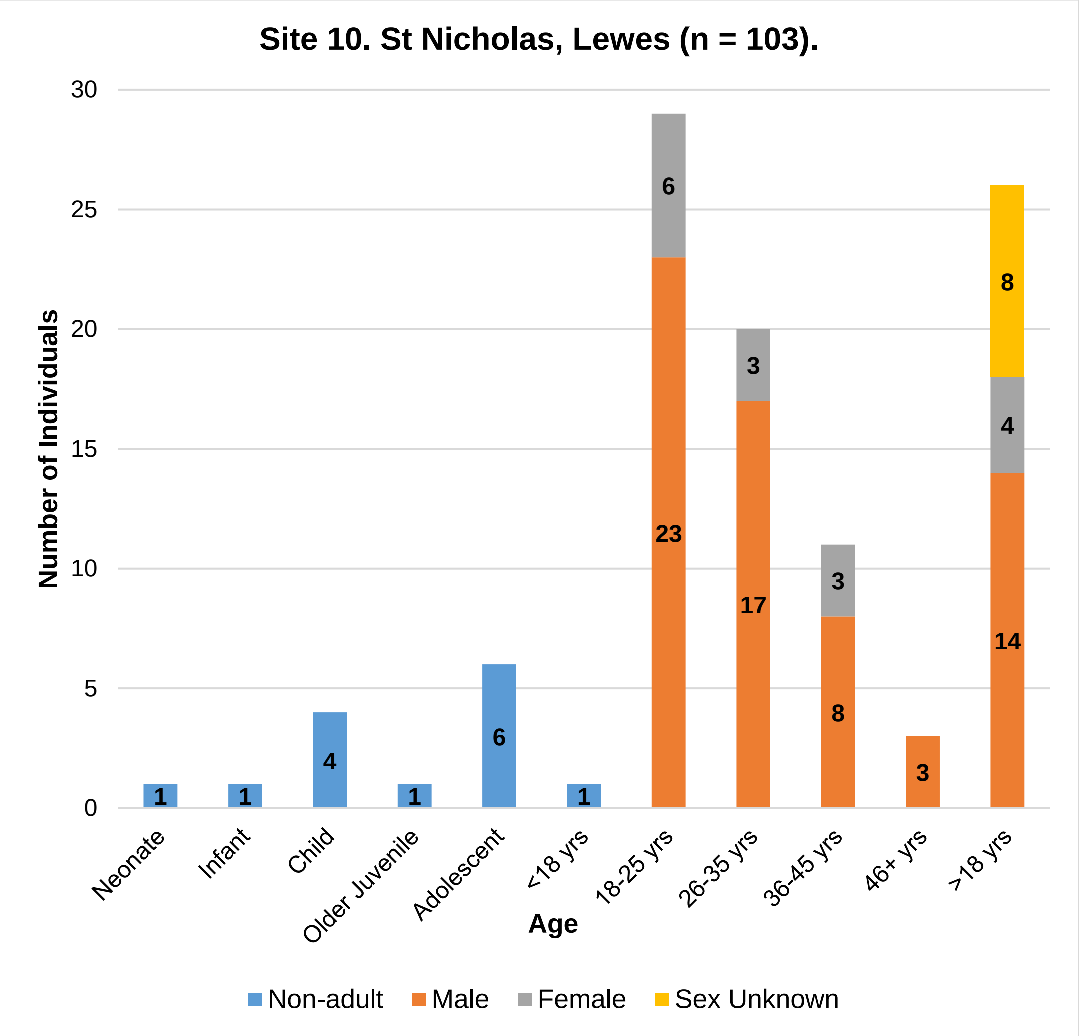
Founded: c.1085.

Dissolved: 1547 (converted to an almshouse).

Date of Cemetery: Late 12th - Early 16th C. Most burials are thought to have occurred during the first two centuries of the cemeteries use.

Population: MNI 103. Adult male: 65. Adult female: 16. Adult sex unknown: 8. Non-adult: 14. One double burial was identified of an adult male [273] and an infant [271].

References: Barber and Sibun, 2010.



Site 11. Crouched Friars, Colchester, Essex.

Hospital Type: Leprosarium and later almshouse, a hospital of the Order of the Holy Cross.

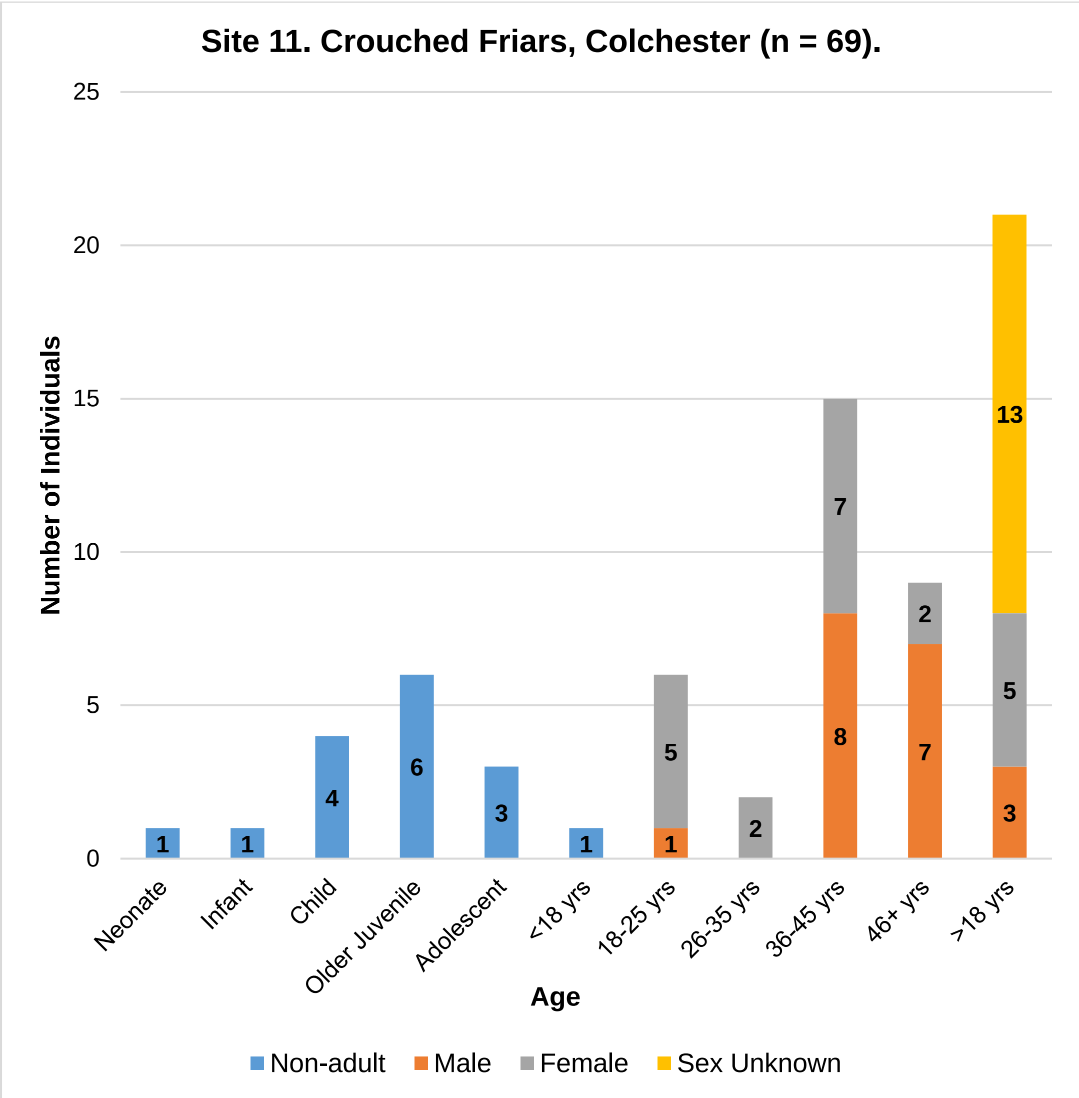
Founded: 1235, re-founded c.1407 (first documentary reference: 1251).

Dissolved: c.1538.

Date of Cemetery: Post 1403 - 1538.

Population: MNI 69. Adult male: 19. Adult female: 21. Adult sex unknown: 13. Non-adult: 16. Two double burials: Grave 07, unsexed adult over 20 years of age and a juvenile aged 3-5 years; Grave 09, unsexed adult over 20 years of age and a juvenile aged under 20 years.

References: Crummy *et al*., 1993; Benfield and Brooks, 2007.



Site 12. St Mary Magdalen, Colchester, Essex.

Hospital Type: Leprosarium and later general hospital, dependent on Colchester Abbey.

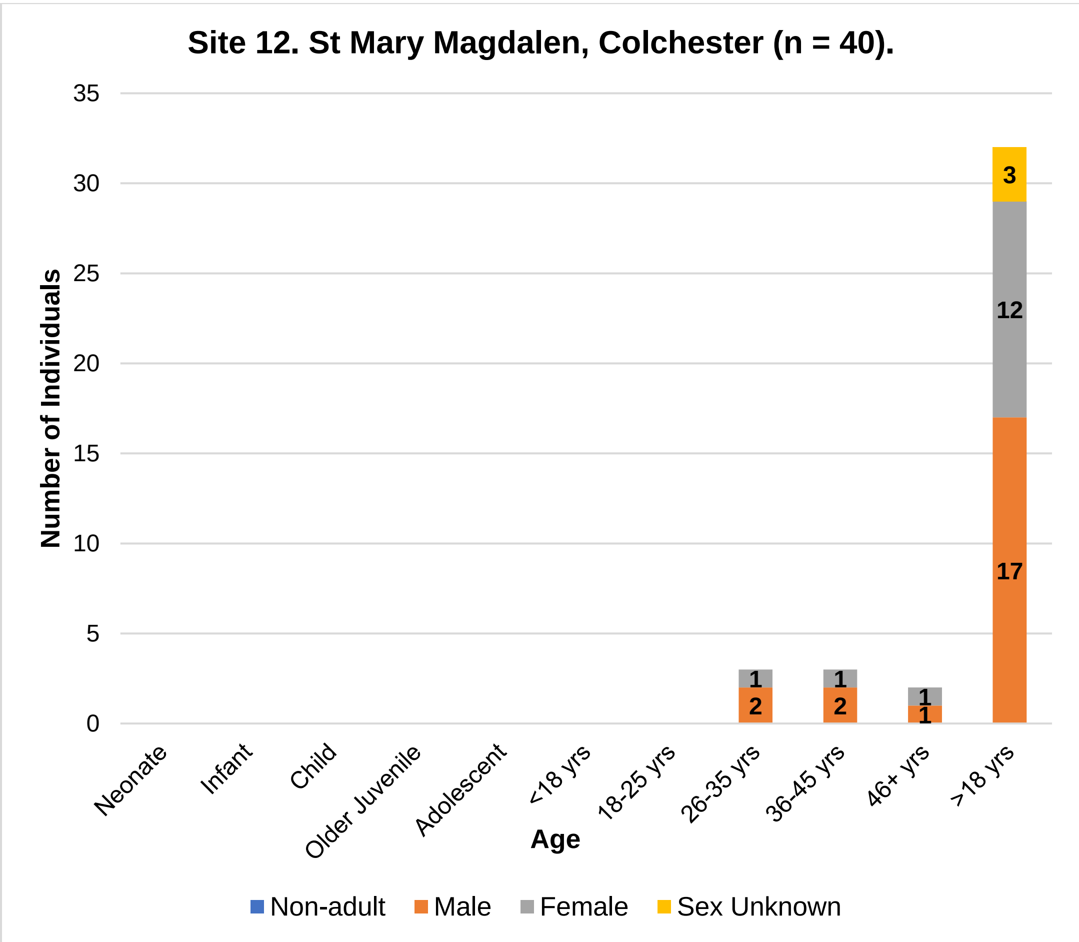
Founded: c.1100.

Dissolved: Pre 1565 (re-founded as an almshouse 1610).

Date of Cemetery: 12th - 20th C. (four phases identified: Phase 1, early 12th - mid 13th C.; Phase 2, mid-13th C. - 1610; Phase 3, 1610 - 19th C.; Phase 4, 19th C. - 1995).

Population: MNI 234. MNI analysed 130. MNI from Phases 1 and 2, 40. Adult male: 22, Adult female: 15, Adult sex unknown: 3, Non-adult: 0. 68 articulated skeletons and 62 individuals from a random sample of individual bones were analysed. The individual bones were unstratified and could date from early 1100's – mid 1800's, however they did contain 15 non-adults (24.19%), demonstrating a different cemetery demography to the articulated skeletons. A 'child's skull' is recorded in the site report (p.114) from the first phase of the cemetery, but this was not included in the osteological analysis.

References: Crossan, 2004.



Site 13. St Mary and St Thomas, Ilford, Essex.

Hospital Type: Leprosarium for men only, dependent of Barking Abbey.

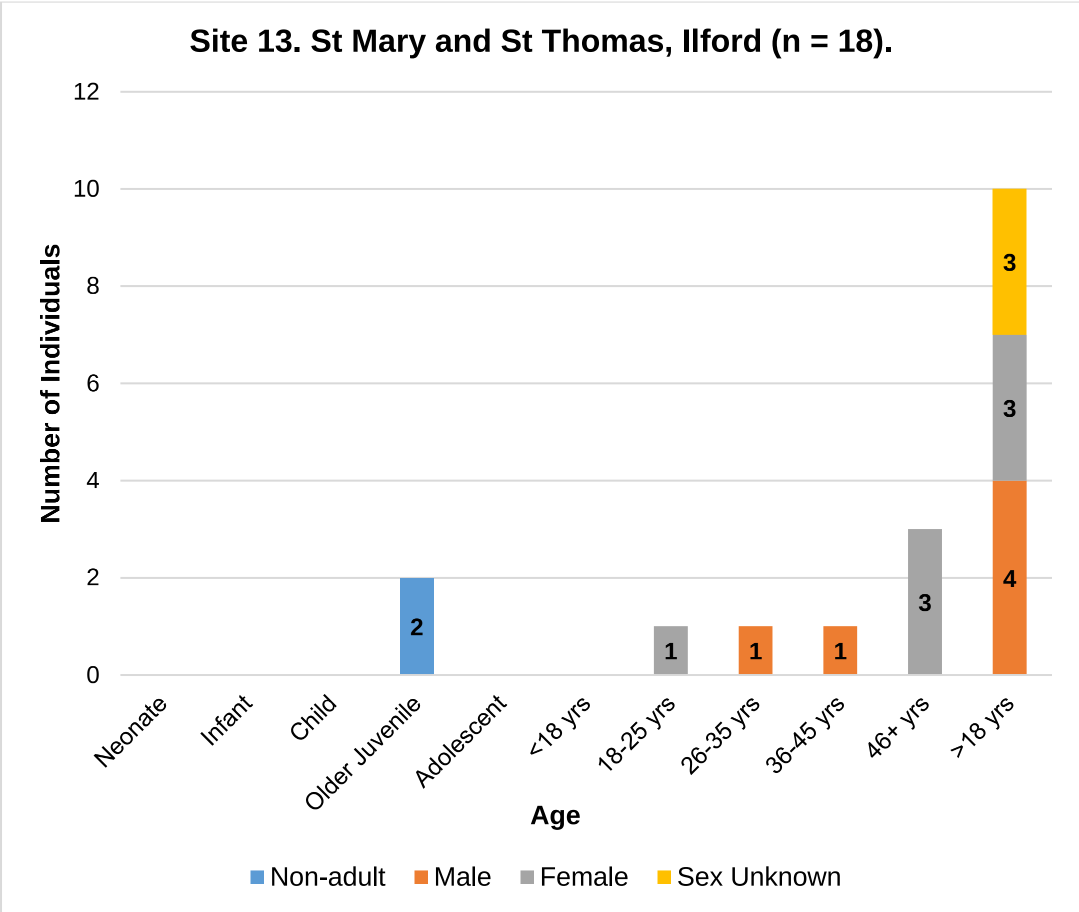
Founded: c.1140.

Dissolved: the hospital survives to the present day as an almshouse.

Date of Cemetery: 1140 - 1538.

Population: MNI 18. Adult male: 6. Adult female: 7. Adult sex unknown: 3. Non-adult: 2. The original record of the excavation (Marshall, 1959/60) records 22 individuals. The excavation plan and subsequent osteological analysis conducted in 1985 (Roberts) do not reconcile. Gilchrist and Sloane (2005) recorded an MNI 9. The MNI for this current report is based on distinct identifiable individuals from Roberts (1985) report and two individuals identified in the 2006 watching brief.

References: Ingram, 2006; Redbridge Museum Archive code ILF59.



Site 14. St Margaret's Chapel, Gloucester, Gloucestershire.

Hospital Type: Leprosarium and later almshouse, dependent of Gloucester Abbey.

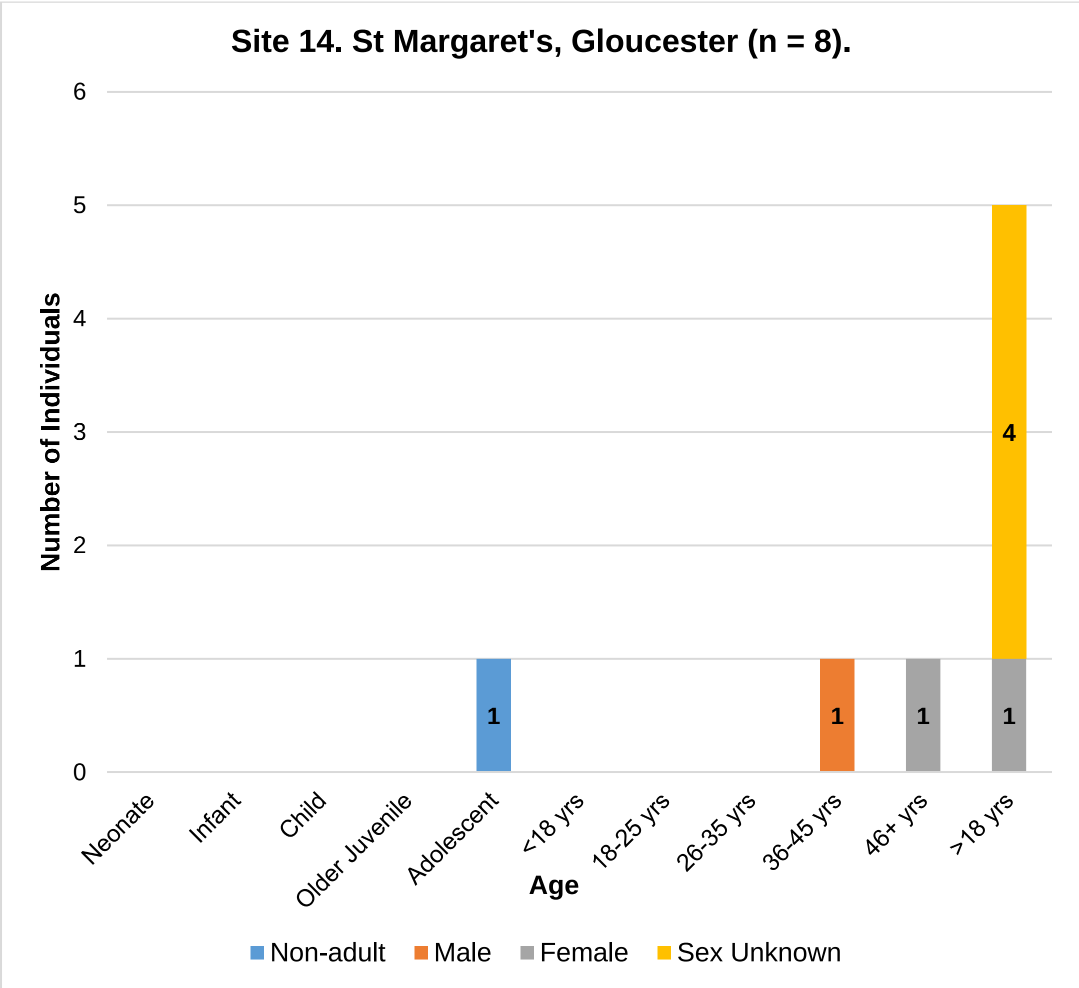
Founded: c.1150 (re-founded as an almshouse at some point after the mid-14th C.).

Dissolved: 1518?

Date of Cemetery: Concurrent with the hospital?

Population: MNI 8. Adult male: 1. Adult female: 2. Adult sex unknown: 4. Non-adult: 1. A possible family group was identified in a single grave, an adolescent (B2) placed between an adult male (B1) and an adult female (B3). The burials may be Roman in date, but it is thought they are more likely to be medieval and associated with the medieval hospital.

References: Atkin and Walters, 1991; Evans, 2006.



Site 15. St John the Baptist, Lechlade, Gloucestershire.

Hospital Type: General hospital, Augustinian rule.

Founded: 1228.

Dissolved: 1472 (converted to a secular chantry).

Date of Cemetery: Concurrent with the hospital?

Population: The site was excavated c.1900 by Mr Wentworth Sturgeon. Over forty skeletons were identified and interpreted as monks. One individual is noted as being female.

References: Gloucestershire County Council HER, 2008.

Site 16. St Mary Magdalene, Winchester, Hampshire.

Hospital Type: Leprosarium and later general hospital.

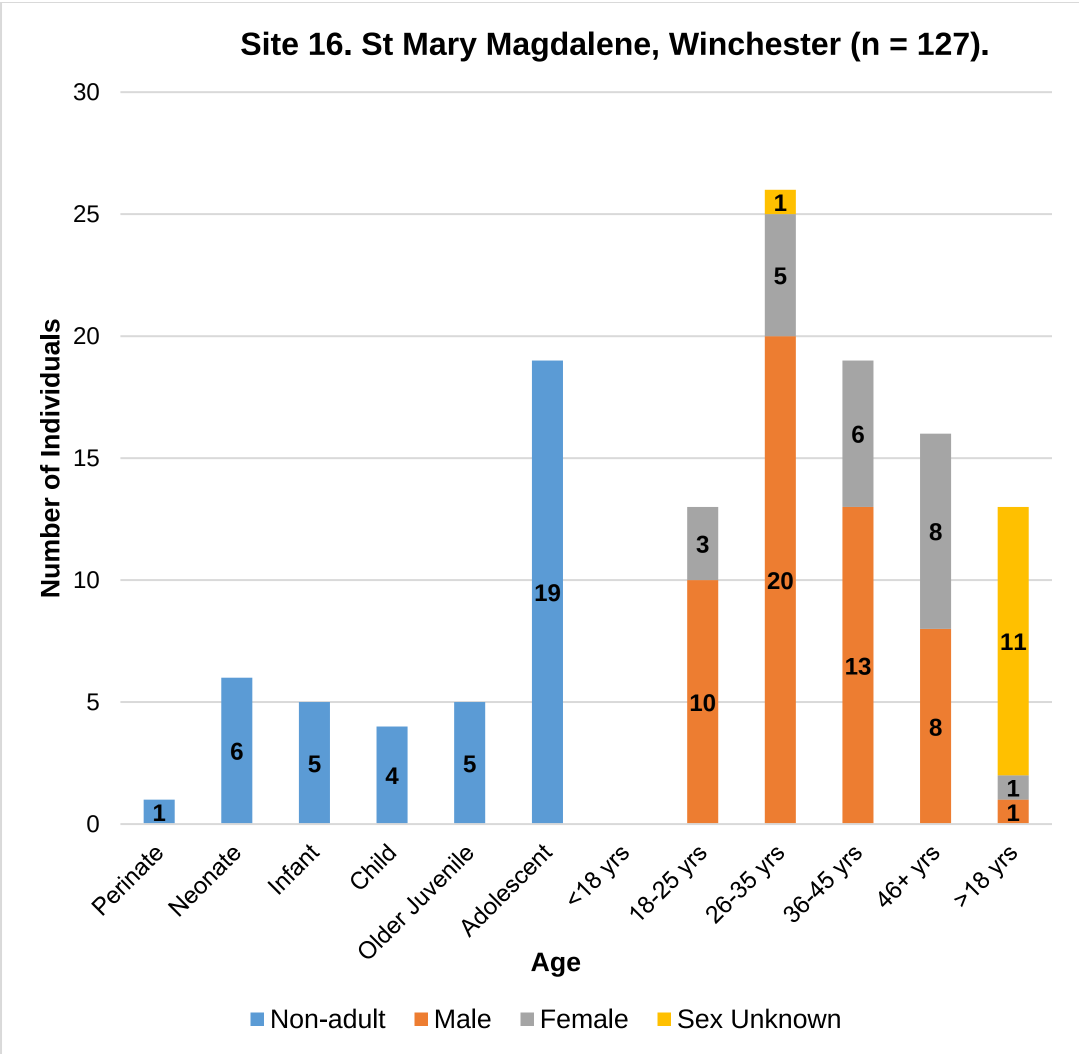
Founded: 1158 (re-founded as a general hospital c.1336; converted to almshouses 16th C.).

Dissolved: 1643 (destroyed during the Civil War).

Date of Cemetery: 11th C. - 16th C.

Population: MNI 127. Adult male: 52. Adult female: 23. Adult sex unknown: 12. Non-adult: 40. A high proportion of the non-adults display evidence for leprosy (18/40, 45%) and delayed skeletal growth (16/40, 40%).

References: Roffey and Tucker, 2012; Tucker, n.d.



Site 17. St Mary Magdalene, Baldock, Hertfordshire.

Hospital Type: Leprosarium for men only, Knights Templar Hospital.

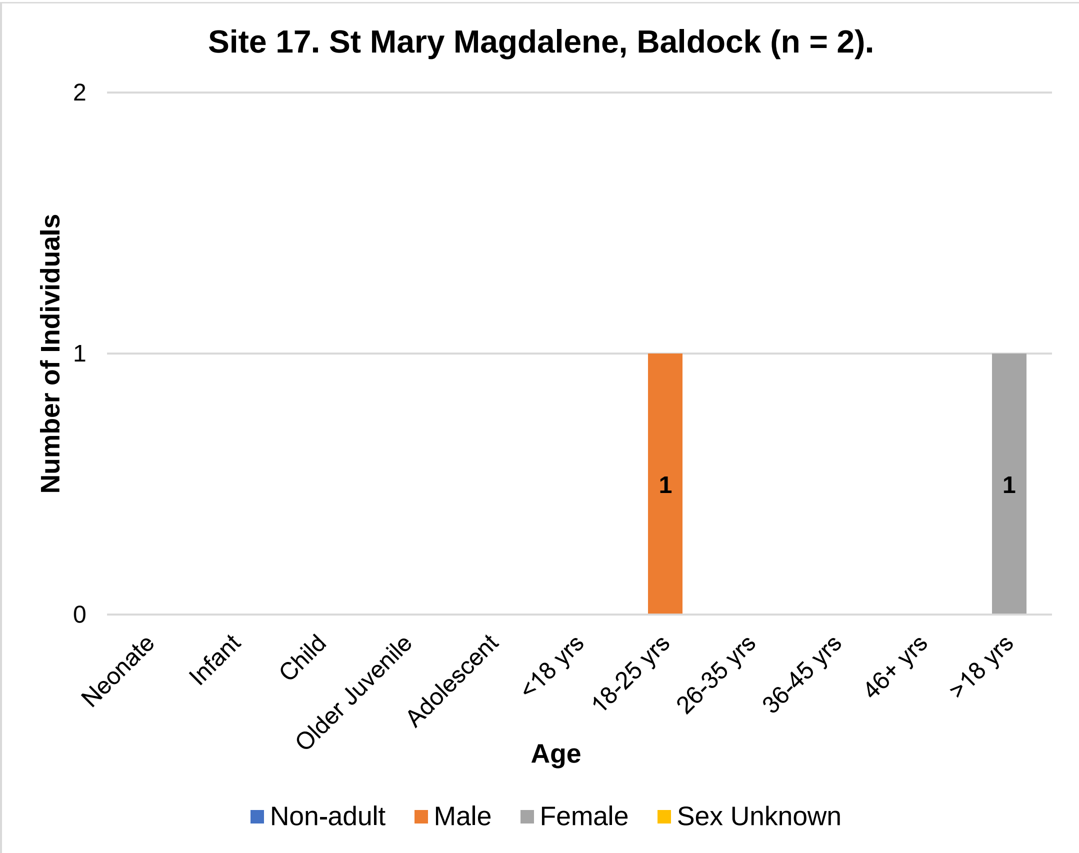
Founded: Post 1200 (first documentary reference: 1226).

Dissolved: c.1307 (the hospital was moved to another site in 1308).

Date of Cemetery: Concurrent with the hospital?

Population: MNI 2. Adult male: 1. Adult female:1. Twelve graves were identified, two were excavated and the skeletons examined *in situ* before being re-covered.

Reference: Thorpe *et al*., 2003.



Site 18. St James or St John the Baptist, Berkhamsted, Hertfordshire.

Hospital Type: Leprosarium, dependent of St Thomas the Martyr, London.

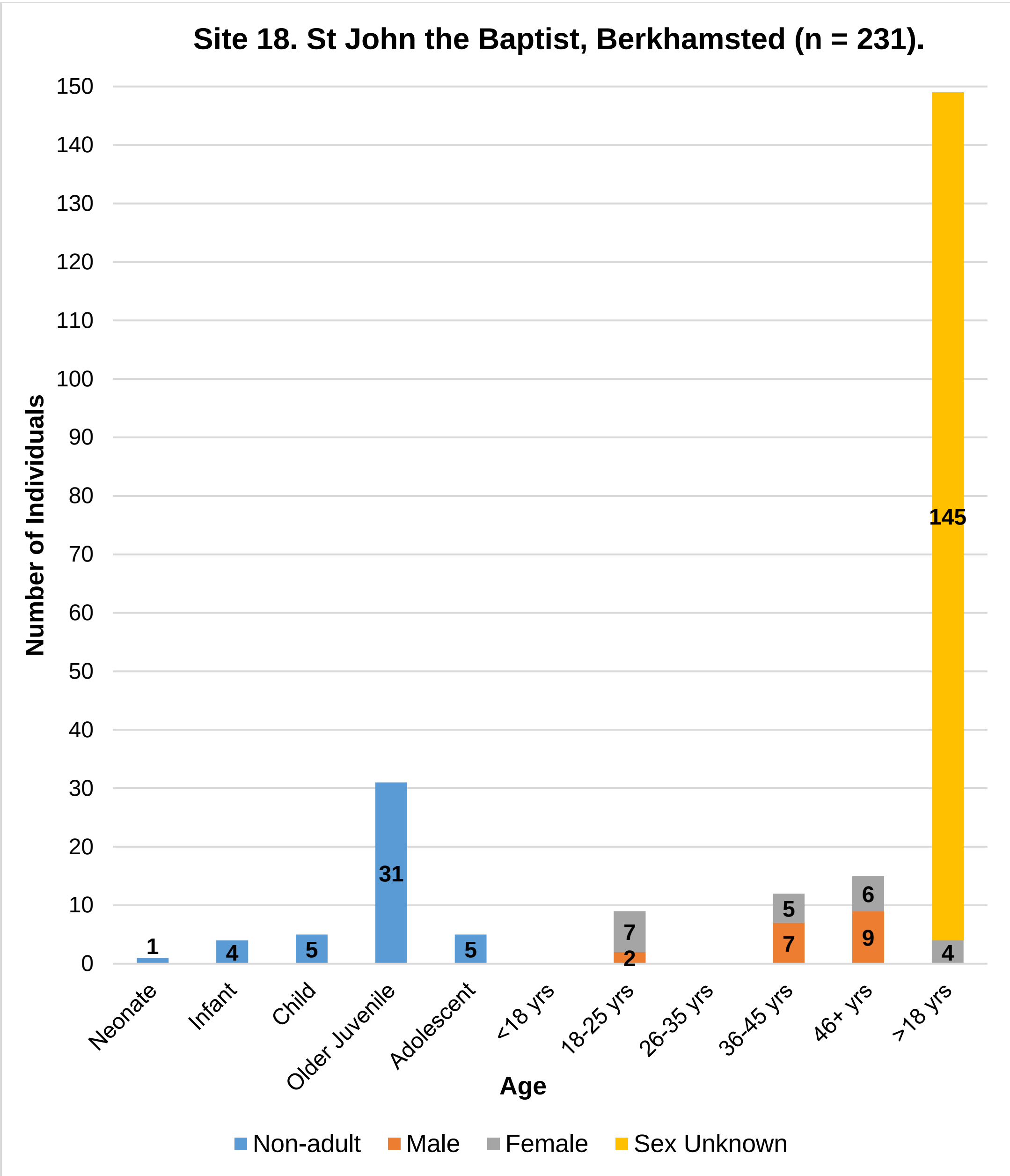
Founded: Pre 1216/17 (first documentary reference: 1216/17).

Dissolved: 1540.

Date of Cemetery: 11th / 12th C. - 15th / 16th C.

Population: MNI 256. MNI analysed 231. Adult male: 18. Adult female: 22. Adult sex unknown: 145. Non-adult: 46. Recorded pathologies and trauma are low in non-adults however the rates of completion are low, with 26/46 (56.5%) at <25%.

Reference: Maher, 2014.



Site 19. St Peter, St Paul and St Thomas the Martyr, Maidstone, Kent.

Hospital Type: General hospital and later almshouse, dependent of Maidstone College.

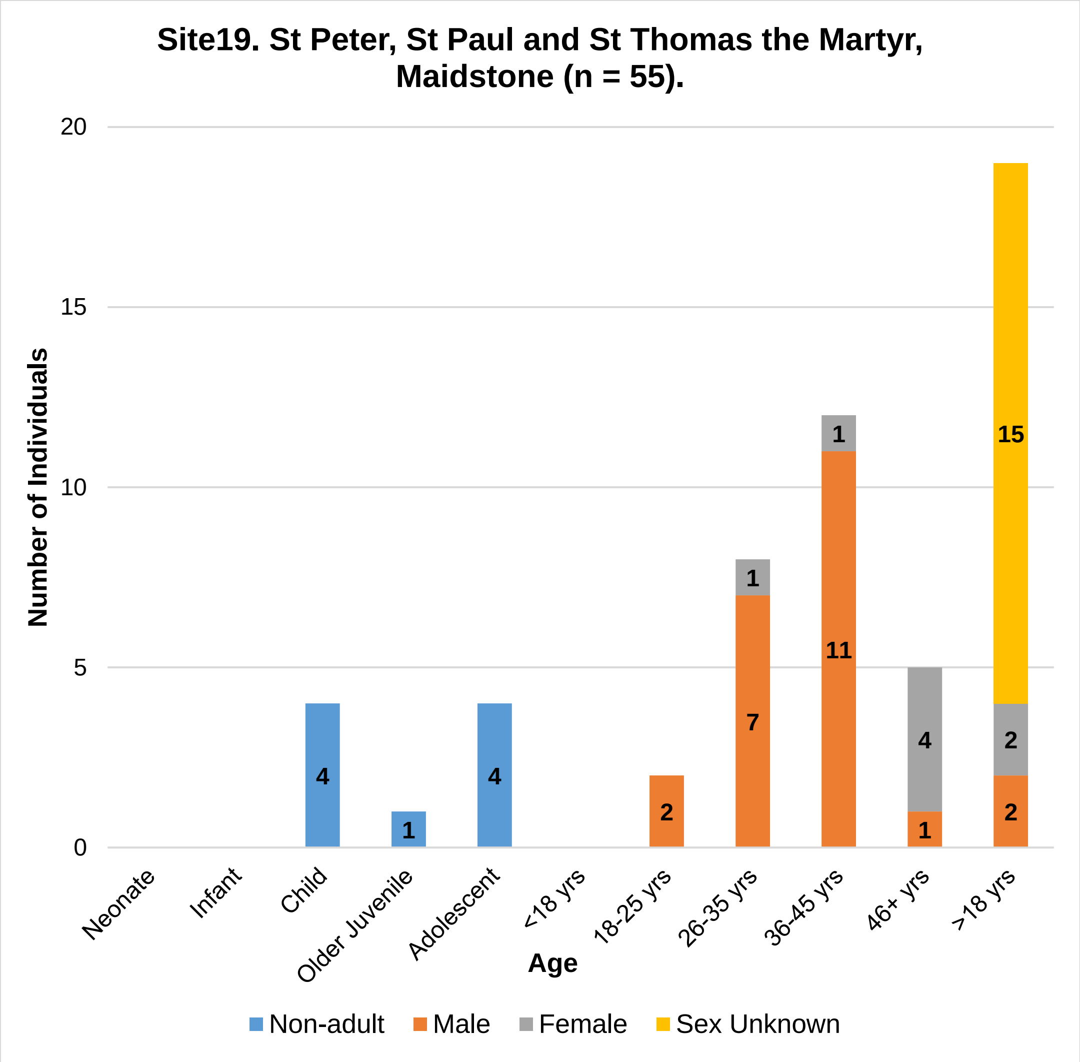
Founded: 1244 or 1260.

Dissolved: 1547 (converted to an almshouse end of 14th C.).

Date of Cemetery: Concurrent with the hospital?

Population: MNI 175. MNI analysed 55. Adult male: 23. Adult female: 8. Adult sex unknown: 15. Non-adult: 9. Disarticulated bone was found at the site and initial assessment indicated a MNI 120, with 85 adults and 35 non-adults.

Reference: Henderson and Knight, 2013.



Site 20. St Stephen and St Thomas, New Romney, Kent.

Hospital Type: Leprosarium and later general hospital.

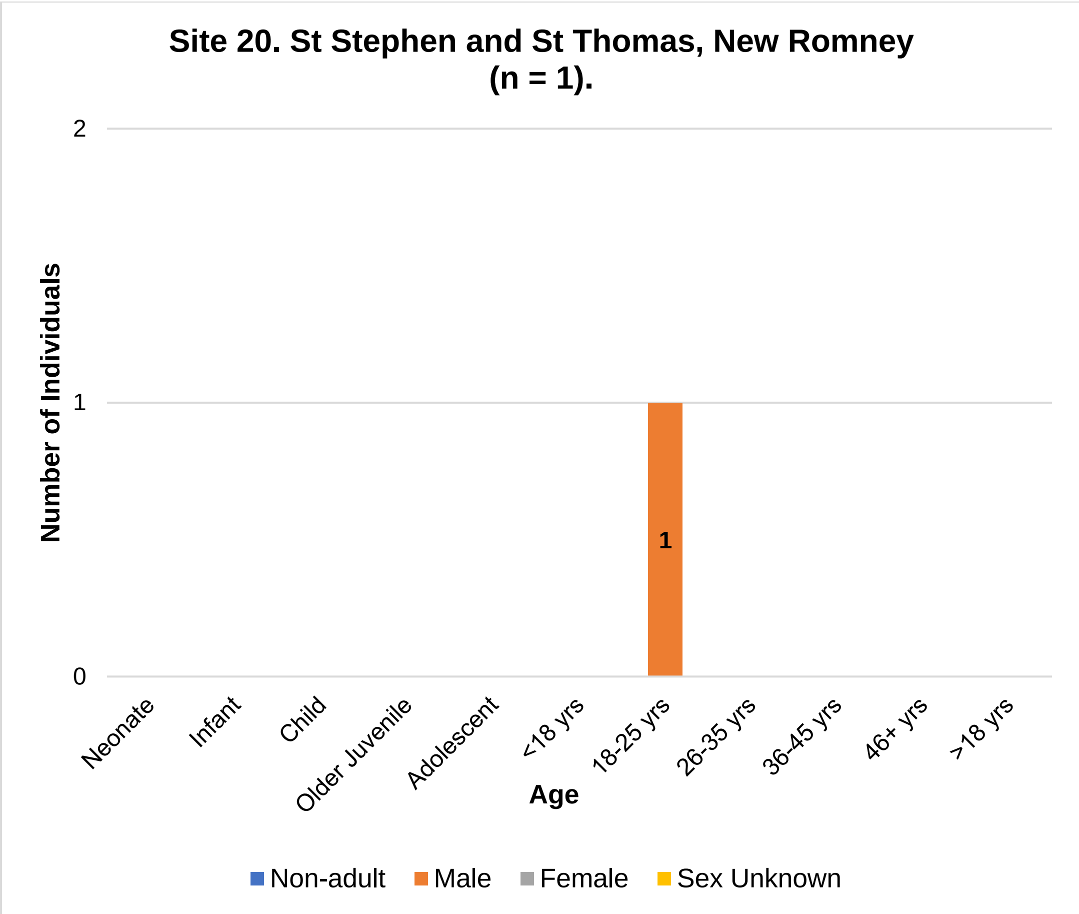
Founded: c.1190 (re-founded c.1363 following a period of decline).

Dissolved: c.1481.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 1. Adult male: 1.

Reference: Holman, 2008.



Site 21. St John, New Romney, Kent.

Hospital Type: General hospital.

Founded: 14th C. (first documentary reference: 1401).

Dissolved: 1495.

Date of Cemetery: Pre 1280 – pre 1495.

Population: MNI 8. Inhumations were encountered during archaeological excavations; they were left *in situ* and no analysis was conducted.

Reference: Holman, 2008.

Site 22. St Mary (commonly known as Maison Dieu), Ospringe, Kent.

Hospital Type: General hospital, Order of the Holy Cross.

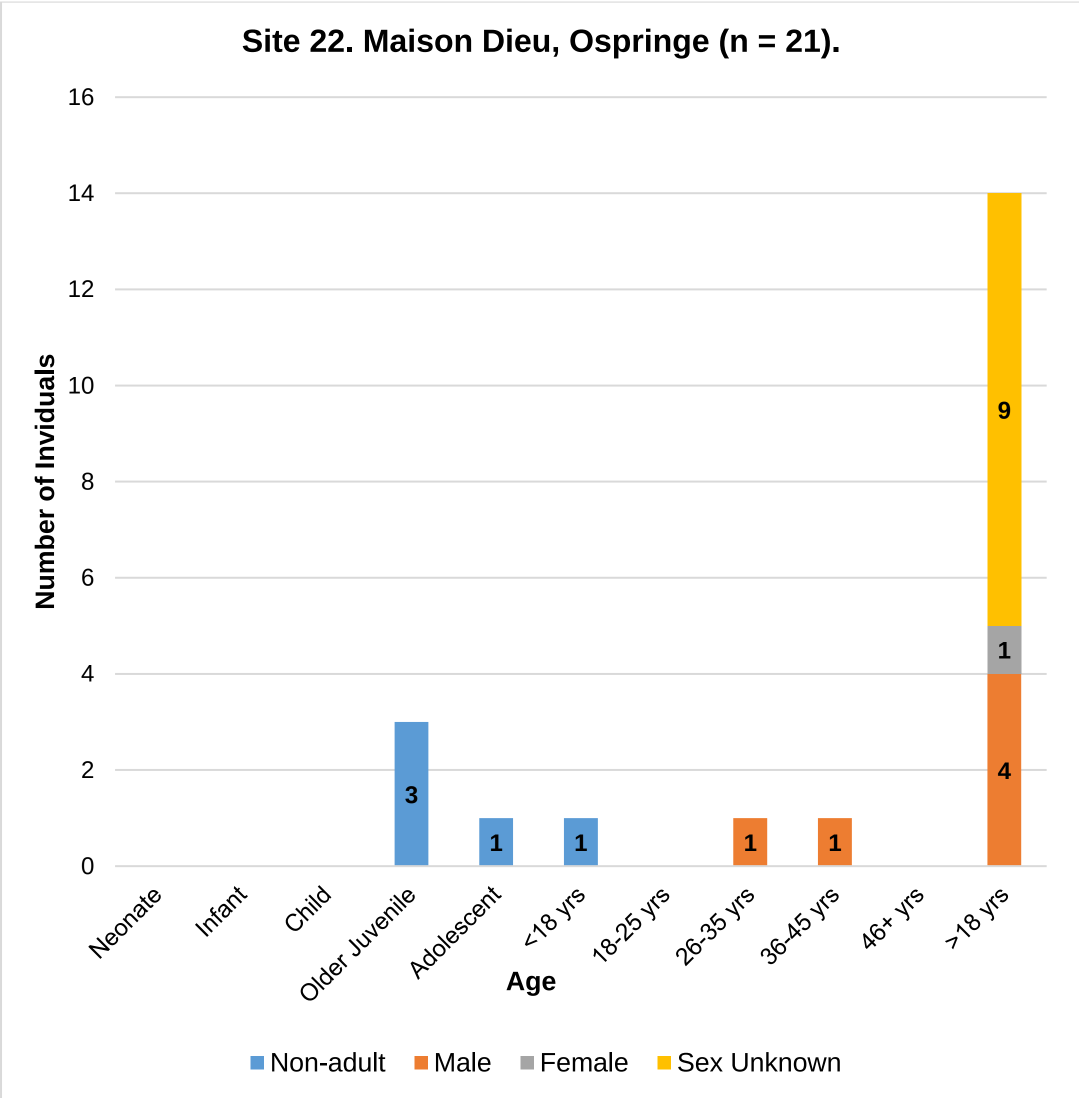
Founded: Pre 1232 (first documentary reference: 1234).

Dissolved: 1516.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 21. Adult male: 6. Adult female: 1. Adult sex unknown: 9. Non-adult: 5. Six burials were identified, two of which were excavated, the additional human remains found were very fragmentary and therefore analysis was limited.

Reference: Smith, 1979.



Site 23. St John the Baptist, Lutterworth, Leicestershire.

Hospital Type: General hospital.

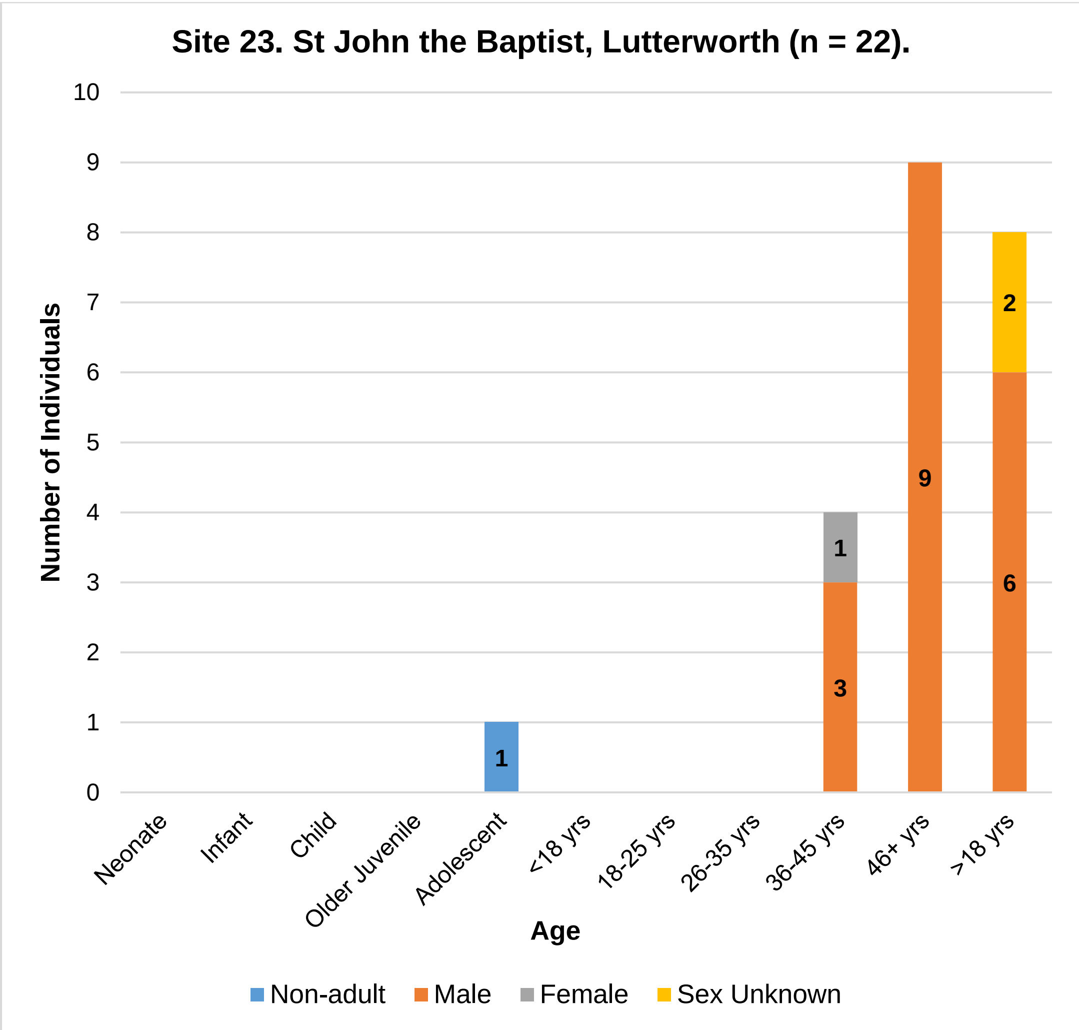
Founded: c.1218.

Dissolved: c.1546 (effectively ceased to function by the end of 14th C.).

Date of Cemetery: 1219 - late 14th C.

Population: MNI 25. MNI analysed 22. Adult male: 18. Adult female: 1. Adult sex unknown: 2. Non-adult: 1. A juvenile (Sk 5) was buried in a supine but inverted position, with the head to the East.

Reference: Priest and Chapman, 2002.



Site 24. St Mary Magdalene, Partney, Lincolnshire.

Hospital Type: General hospital, dependent of Bardney Abbey.

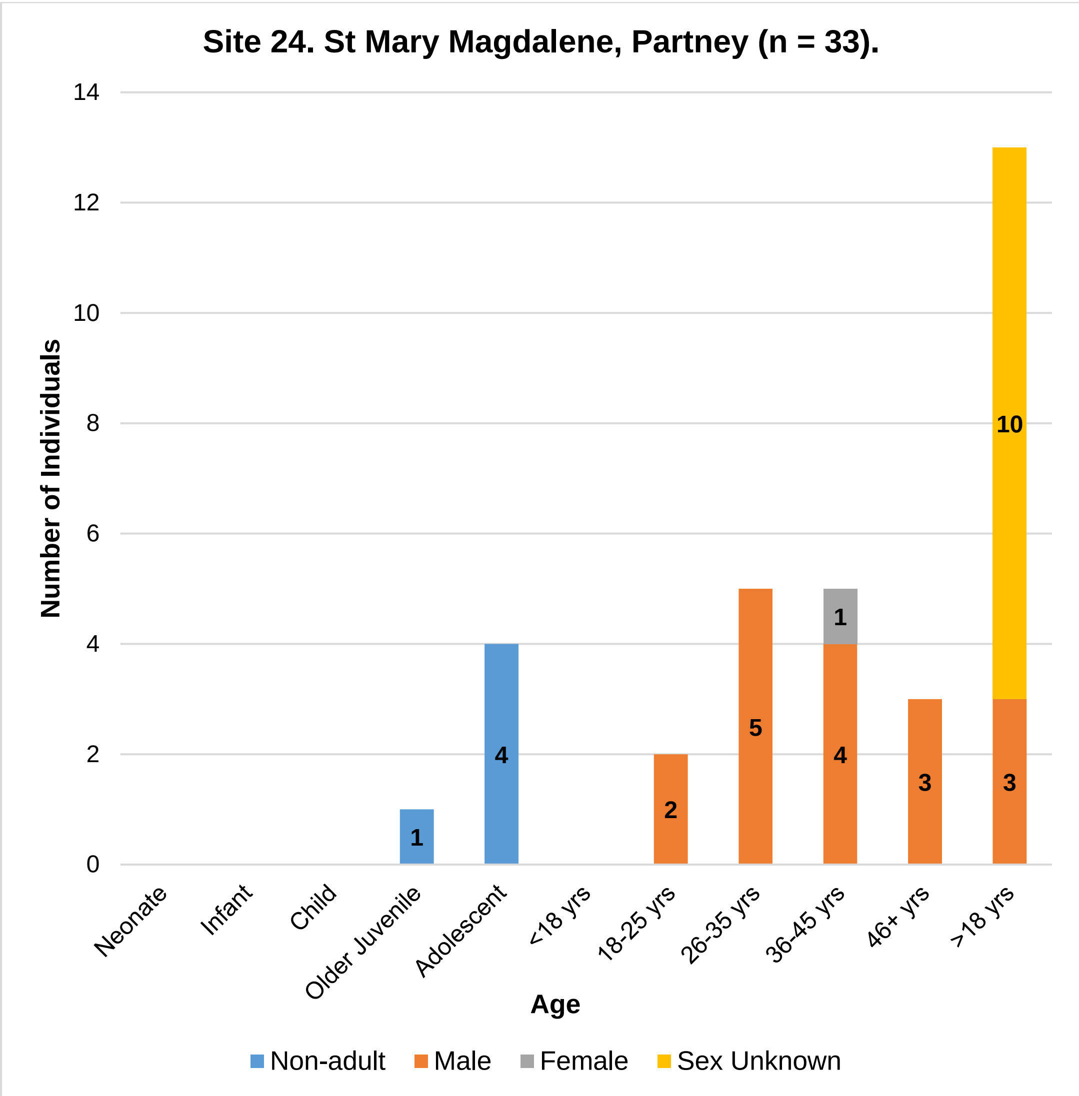
Founded: Post 1115.

Dissolved: 1318.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 33. Adult male: 17. Adult female: 1. Adult sex unknown: 10. Non-adult: 5. The cemetery was laid out in two areas with priestly or monk burials to the south of a path and lay burials to the north.

Reference: Atkins, 2005; Atkins and Popescu, 2010.



Site 25. St Giles, Lincoln, Lincolnshire.

Hospital Type: General hospital and later for aged priests.

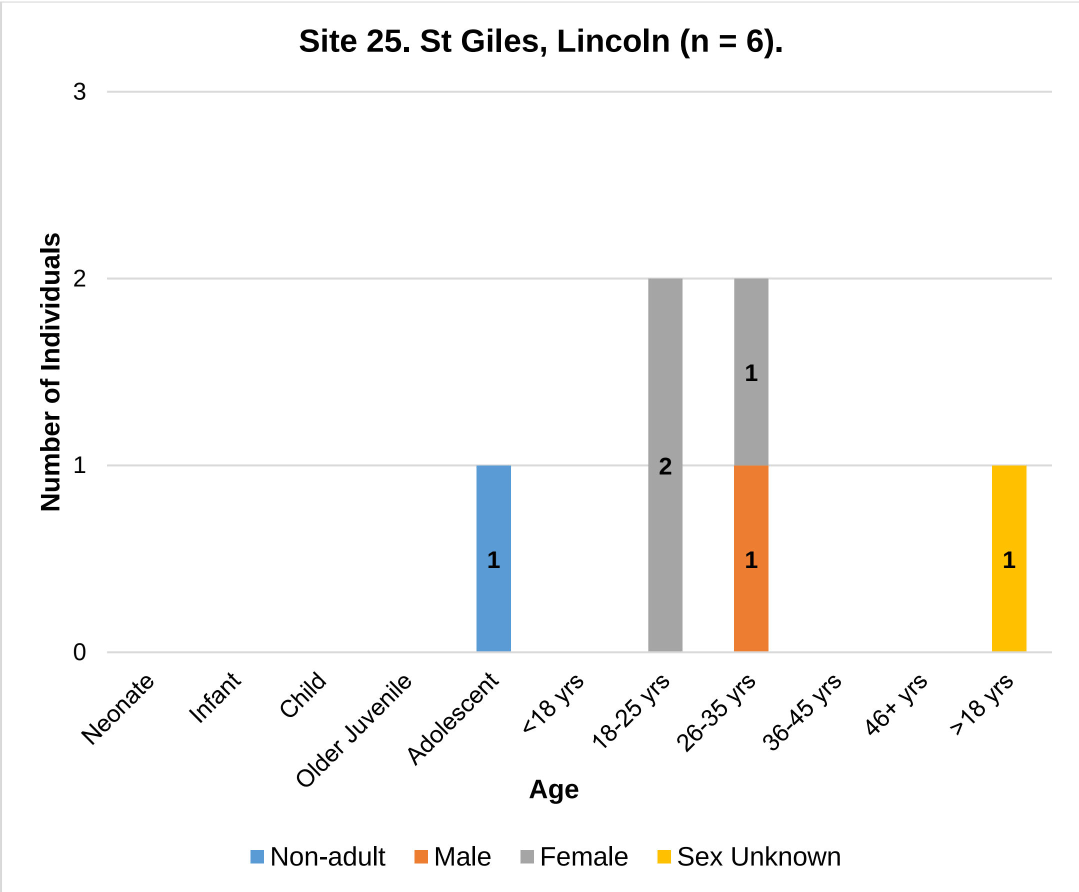
Founded: c.1275 (Aged priests were admitted in preference to others: c.1384)

Dissolved: The hospital had diminished by 1453.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 6. Adult male: 1. Adult female: 3. Adult sex unknown: 1. Non-adult: 1. A further four individuals were identified but were not at risk by development and were left *in situ*. An adolescent (Sk 1) possible had second stage syphilis. An adult female (Sk 5) was buried with a metal armlet which would have fitted a juvenile and has been interpreted as a grave good, possibly placed in the grave by a younger family member.

Reference: Allen Archaeology, 2012.



Site 26. St Mary Spital, London, Middlesex.

Hospital Type: General hospital, Augustinian rule.

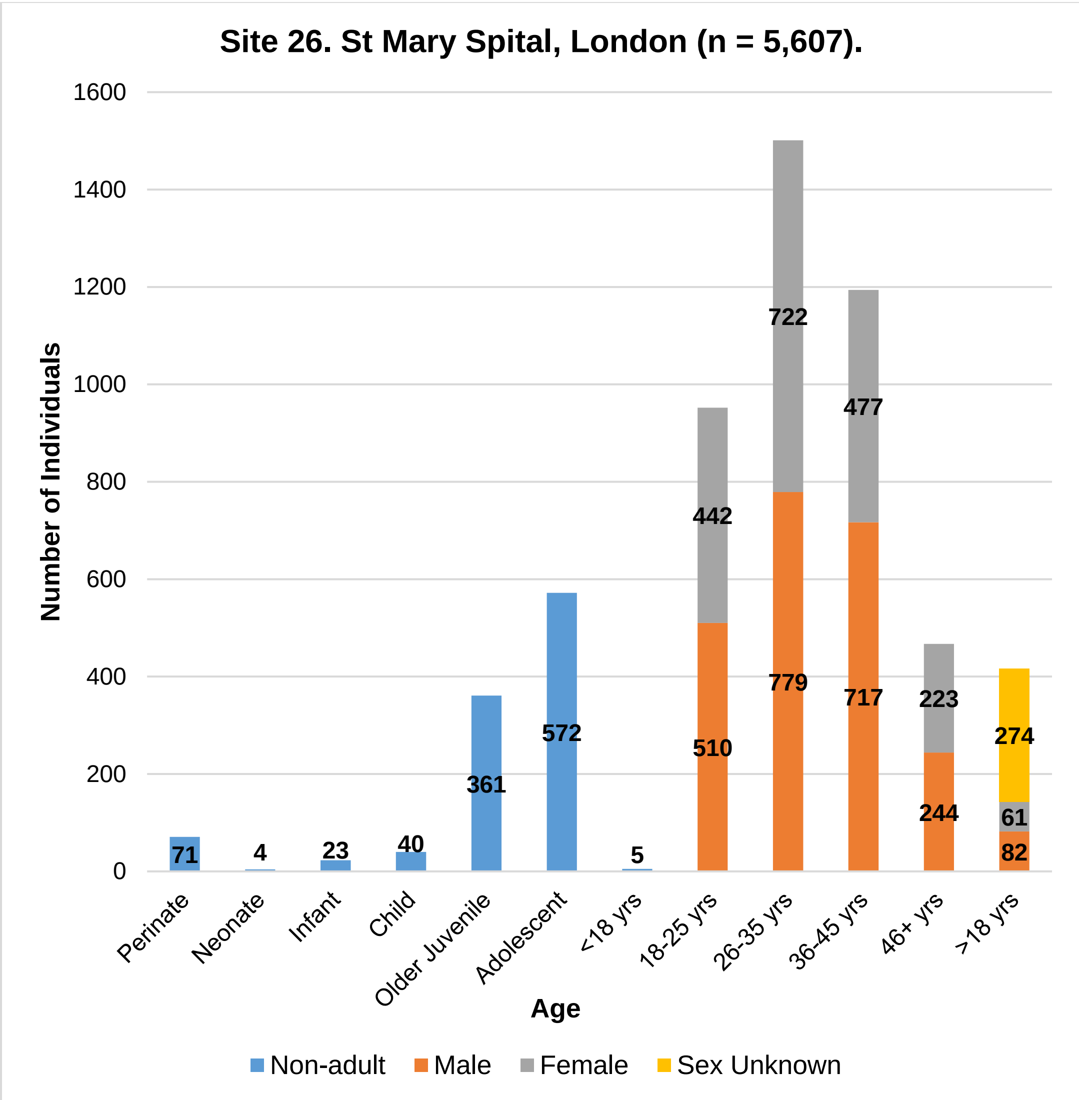
Founded: 1197.

Dissolved: 1539.

Date of Cemetery: c.1120 – 1539. Four phases of cemetery use were identified: Period 14, c.1120 – c.1200; Period 15, c.1200 – 1250; Period 16, c.1250 – c.1400; Period 17 c.1400 – 1539.

Population: MNI: 10,389. MNI analysed 5,607. Adult male: 2,332. Adult female: 1,925. Adult sex unknown: 274. Non-adult: 1,076. Approximately half of the individuals were buried in single graves and the other half were buried in graves or pits classified as catastrophe burials containing between two and forty-five individuals. A high proportion of juveniles (n = 377) and adolescents (n = 572) were identified.

References: Thomas *et al*., 1997; Connell *et al*., 2012; Centre for Human Bioarchaeology, 2013.



Site 27. St Bartholomew, Castle Acre, Norfolk.

Hospital Type: Leprosarium, dependent of Castle Acre Priory.

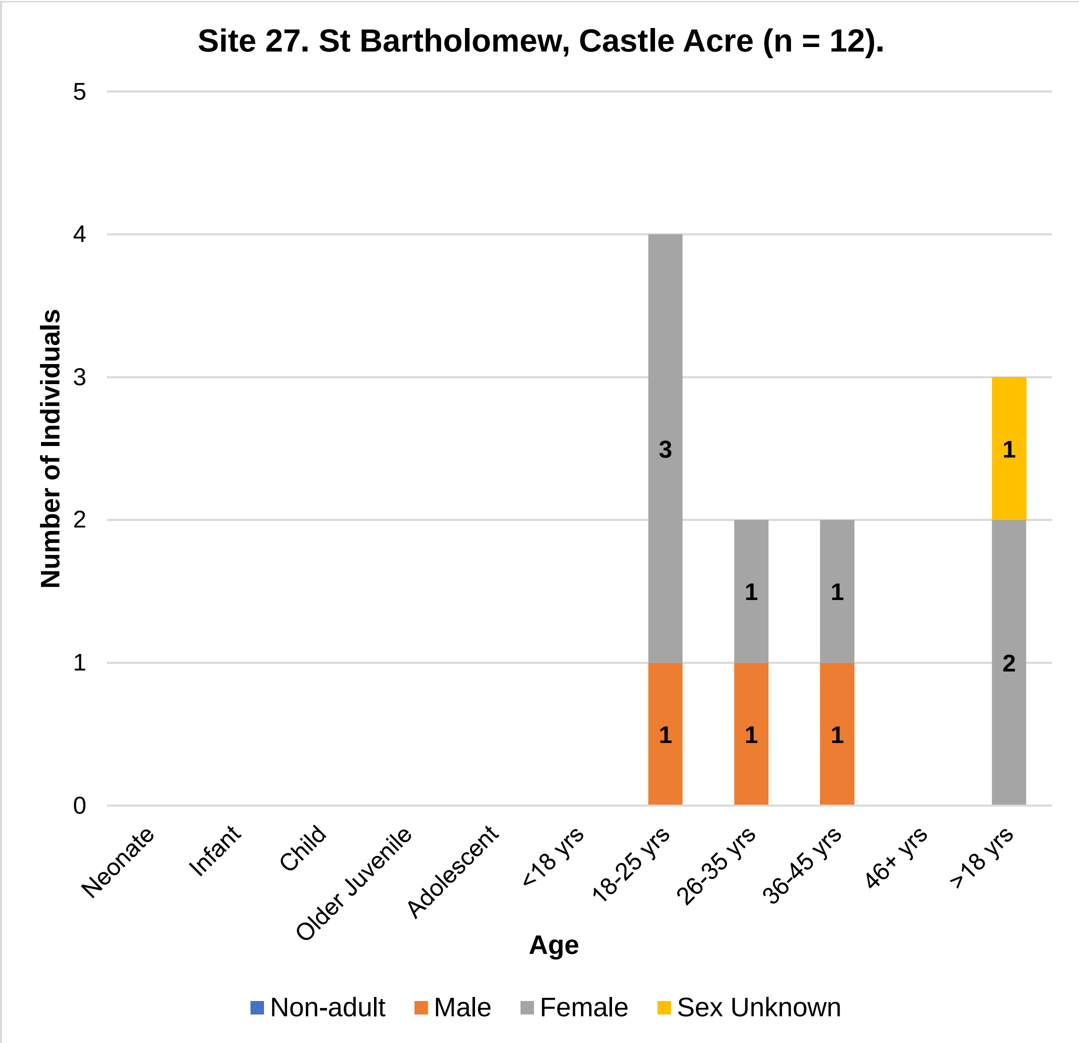
Founded: 12th C.

Dissolved: c.1350.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 12. Adult male: 3. Adult female: 7. Adult sex unknown: 1. Non-adult: 0. 1 individual age and sex unknown.

Reference: Wells, 1967.



Site 28. St Giles, Brough, North Yorkshire.

Hospital Type: General hospital for men, also housed lepers and travellers.

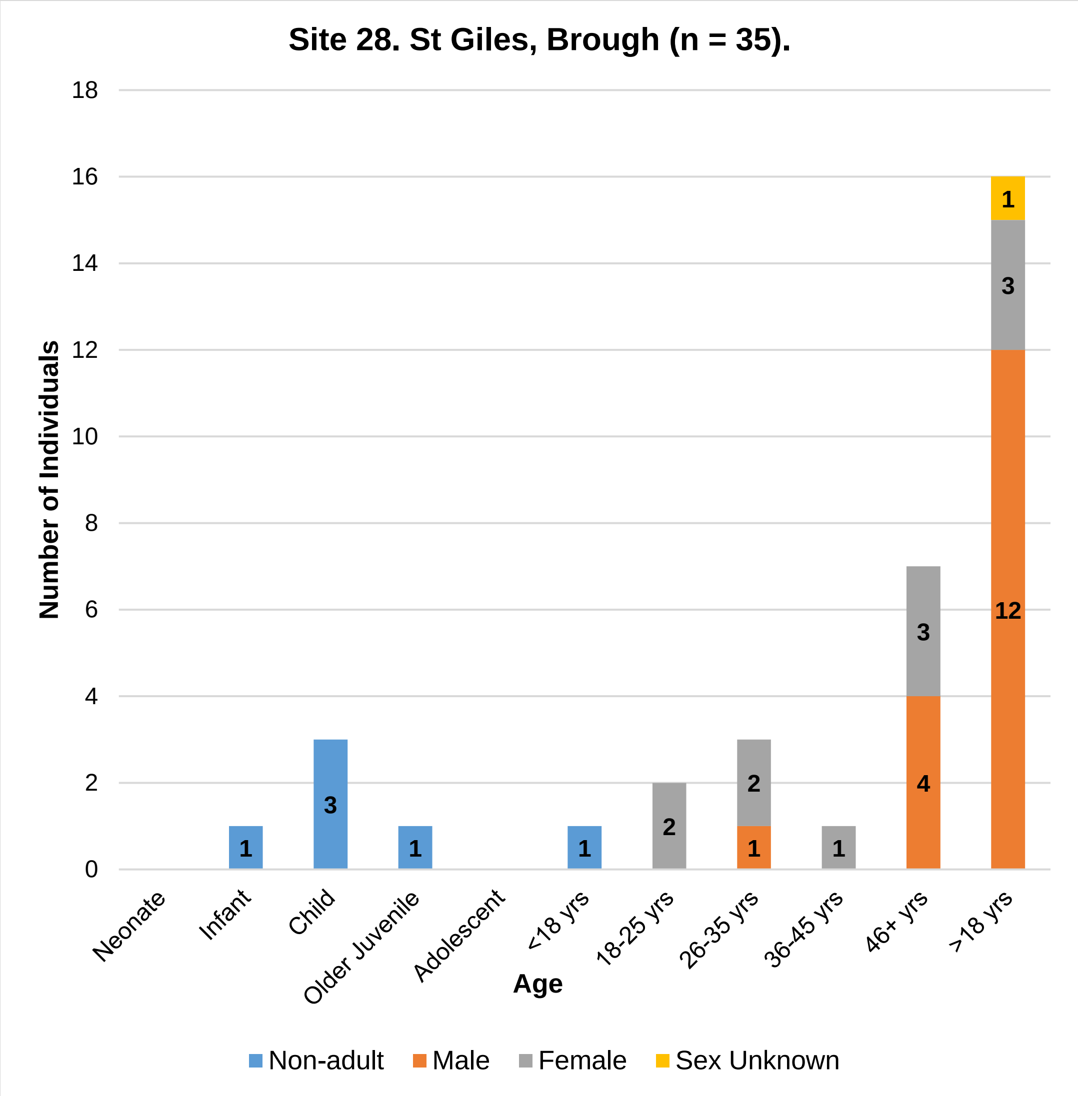
Founded: Late 12th C. (first documentary reference: c.1220).

Dissolved: Late 15th C.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 37. MNI analysed 35. Adult male: 17. Adult female: 11. Adult sex unknown: 1. Non-adult: 6. A further seven graves were identified but not excavated, a foetal individual was also identified but was not included in the original osteological analysis of the site.

Reference: Cardwell, 1996.



Site 29. St Mary, Staxton, North Yorkshire.

Hospital Type: Unknown, dependent of Priory of Bridlington.

Founded: 12th - 13th C.

Dissolved: Pre 1535.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 1, age and sex unknown. A further four graves were identified, and a number of disarticulated human remains were found. No additional information is given in the site report.

Reference: Brewster, 1951.

Site 30. St Mary, York, North Yorkshire.

Hospital Type: Almshouse for poor priests.

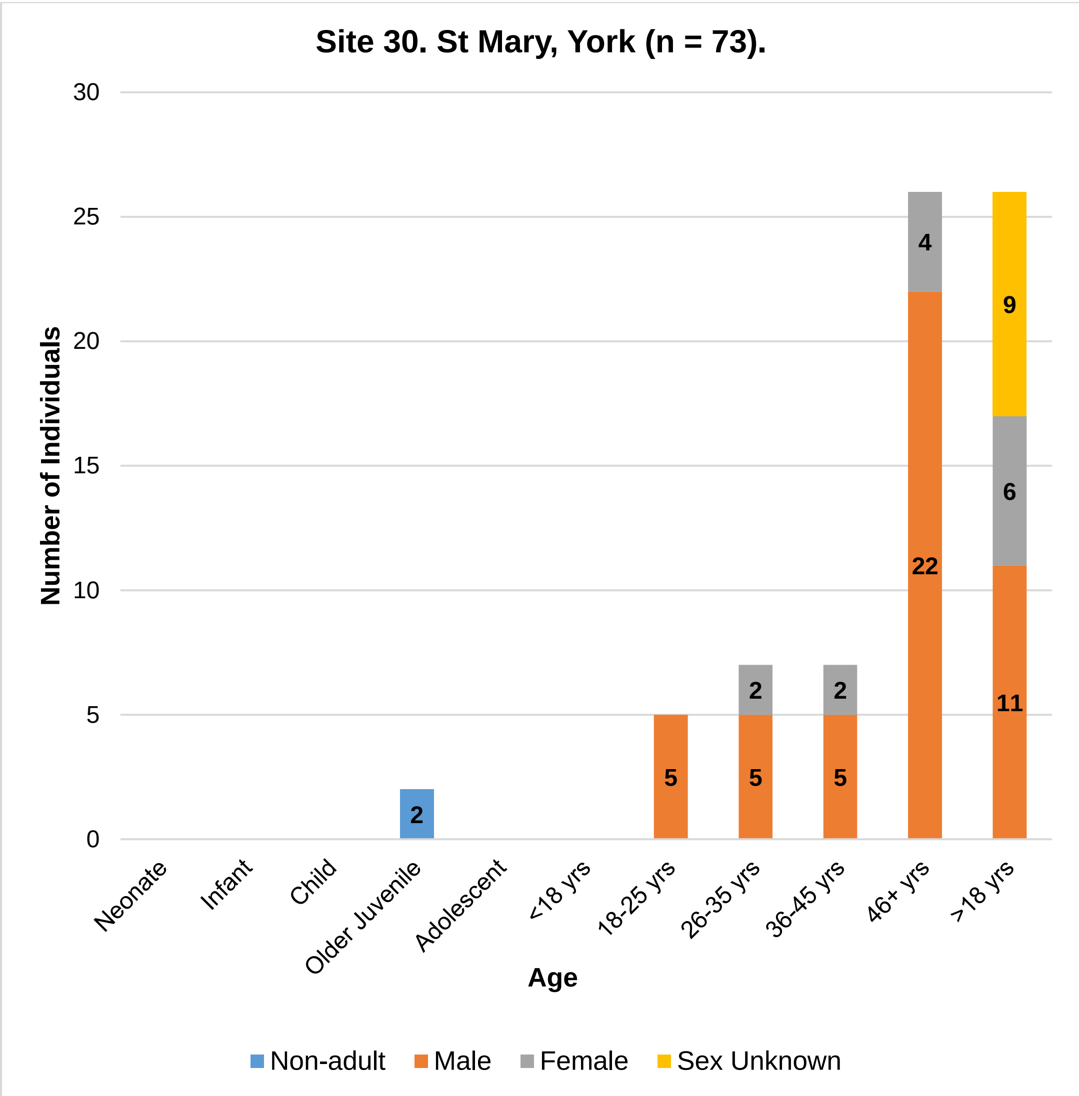
Founded: 1318.

Dissolved: c.1535 (converted to St Peter's School 1557).

Date of Cemetery: Concurrent with the hospital?

Population: MNI 76. MNI analysed 73. Adult male: 48. Adult female: 14. Adult sex unknown: 9. Non-adult: 2. Due to the low number of non-adults identified at this site, they have been interpreted as potential staff or workers serving the priests.

Reference: Richards *et al.*, 1989.



Site 31. St Leonard, Newark, Nottinghamshire.

Hospital Type: Leprosarium for men only, then a general hospital, and later almshouse.

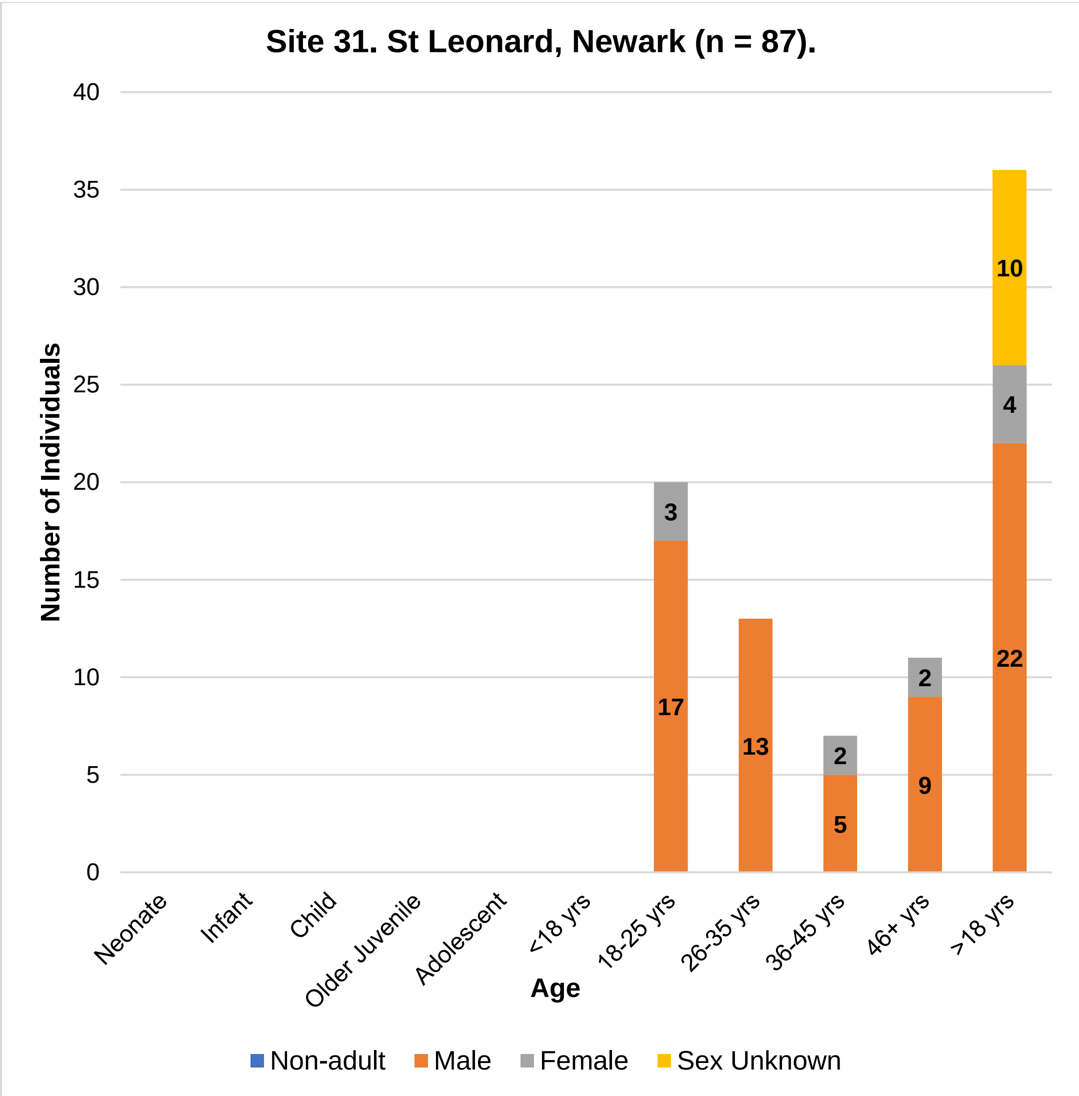
Founded: 1125 (re-founded as a general hospital 1323, and again as an almshouse 1477).

Dissolved: c.1640.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 87. Adult male: 66. Adult female: 11. Adult sex unknown: 10. Non-adult: 0.

Reference: Bishop, 1983.



Site 32. St Mary Magdalene, Bawtry, South Yorkshire.

Hospital Type: General hospital.

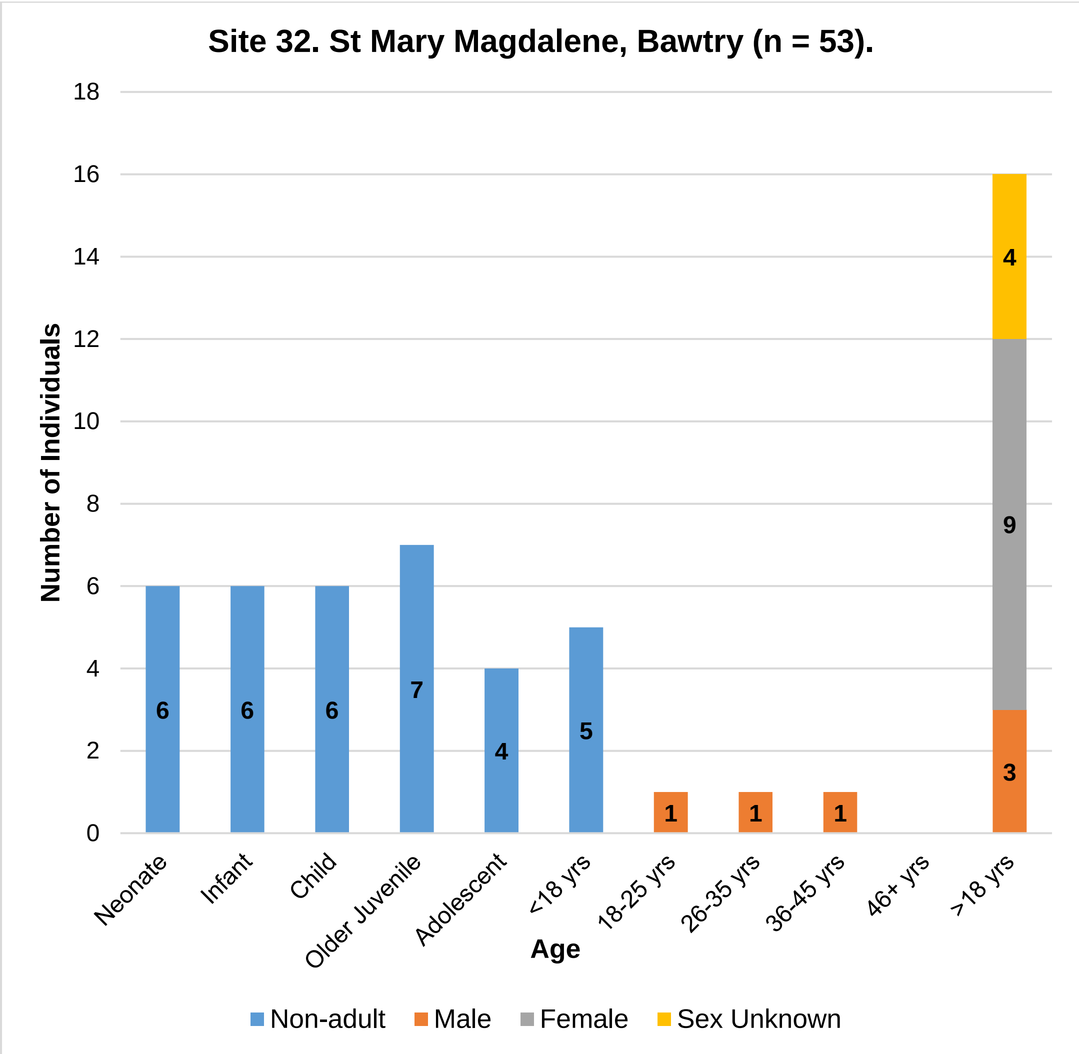
Founded: 13th C.

Dissolved: 1685 (continued as an almshouse into the 19th C.).

Date of Cemetery: Concurrent with the hospital?

Population: MNI 53. Adult male: 6. Adult female: 9. Adult sex unknown: 4. Non-adult: 34. 17 articulated inhumations and 35 individuals from disarticulated remains were analysed. The excavators hypothesised that the high proportion of non-adults identified at this site may be due to the location of the excavation trench in close proximity to the church.

Reference: McIntyre and Hadley, 2012.



Site 33. St James, Doncaster, South Yorkshire.

Hospital Type: Leprosarium and later general hospital, dependent of the Order of St Thomas the Martyr of Acon.

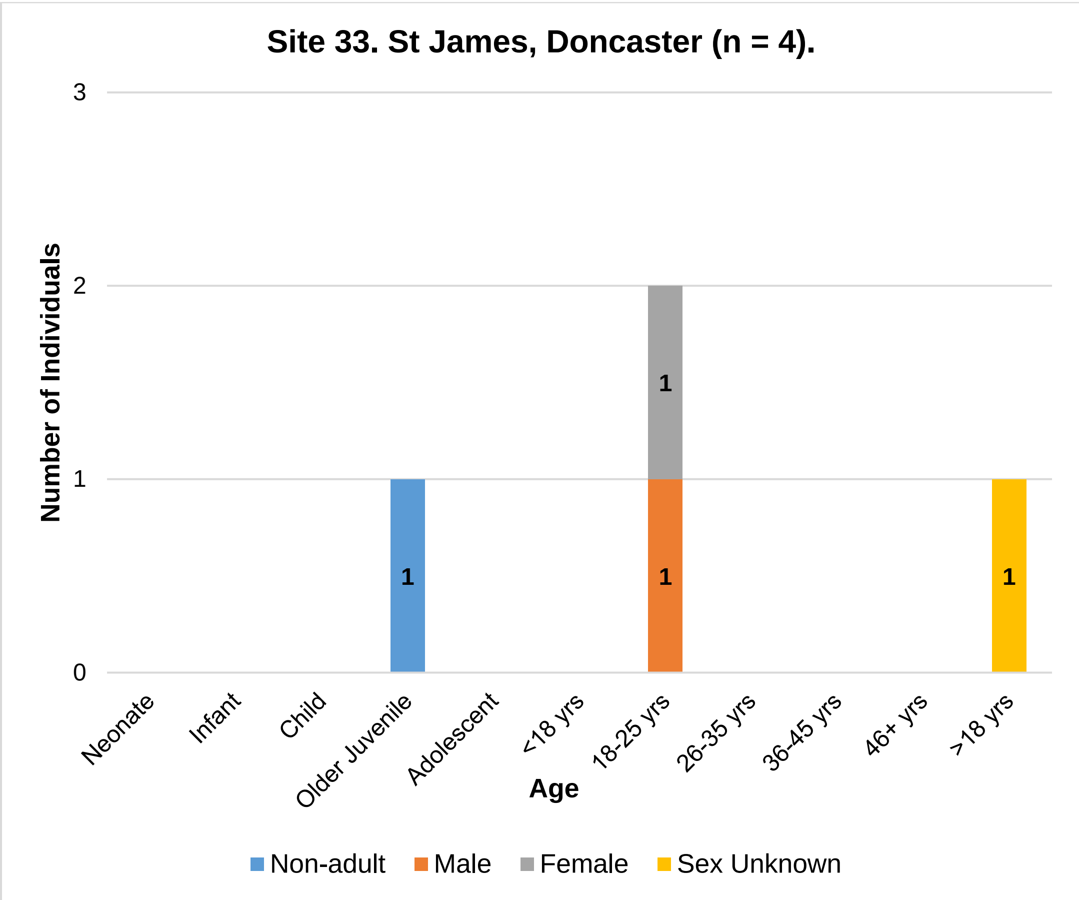
Founded: 1222.

Dissolved: 1547.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 4. Adult male: 1. Adult female: 1. Adult sex unknown: 0. Non-adult: 1. 1 individual age and sex unknown.

Reference: Buckland *et al.*, 1989.



Site 34. St John the Baptist, Lichfield, Staffordshire.

Hospital Type: General hospital and later almshouse for men.

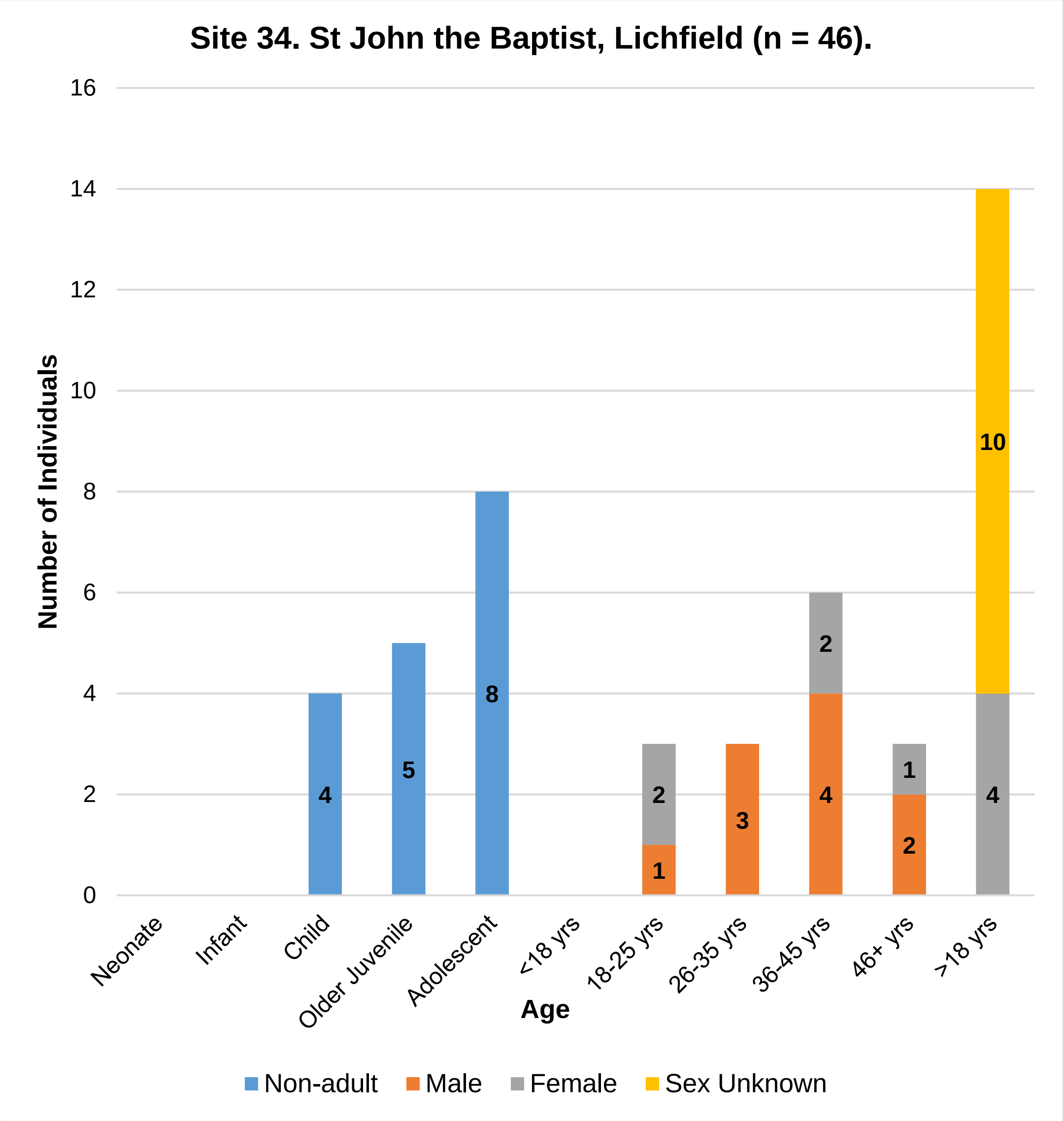
Founded: c.1135 (first documentary reference: 1208).

Dissolved: c.1571 (documents state the hospital was then allocated to support 10 almsmen).

Date of Cemetery: 12th - 14th C.

Population: MNI 46. Adult male: 10. Adult female: 9. Adult sex unknown: 10. Non-adult: 17. Four individuals were of African or mixed-race ancestry.

Reference: Goacher *et al*., 2016.



Site 35. St John or St Louis or St Eloy, Stoke-on-Trent, Staffordshire.

Hospital Type: Unknown.

Founded: c.13th C?

Dissolved: Post 1545.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 21. Due to poor preservation no osteological analysis could be conducted.

Reference: Duncan, 2002.

Site 36. St Peter's, Bury St Edmunds, Suffolk.

Hospital Type: Leprosarium for aged, infirm, and leprous priests, dependent of Bury St Edmunds Abbey.

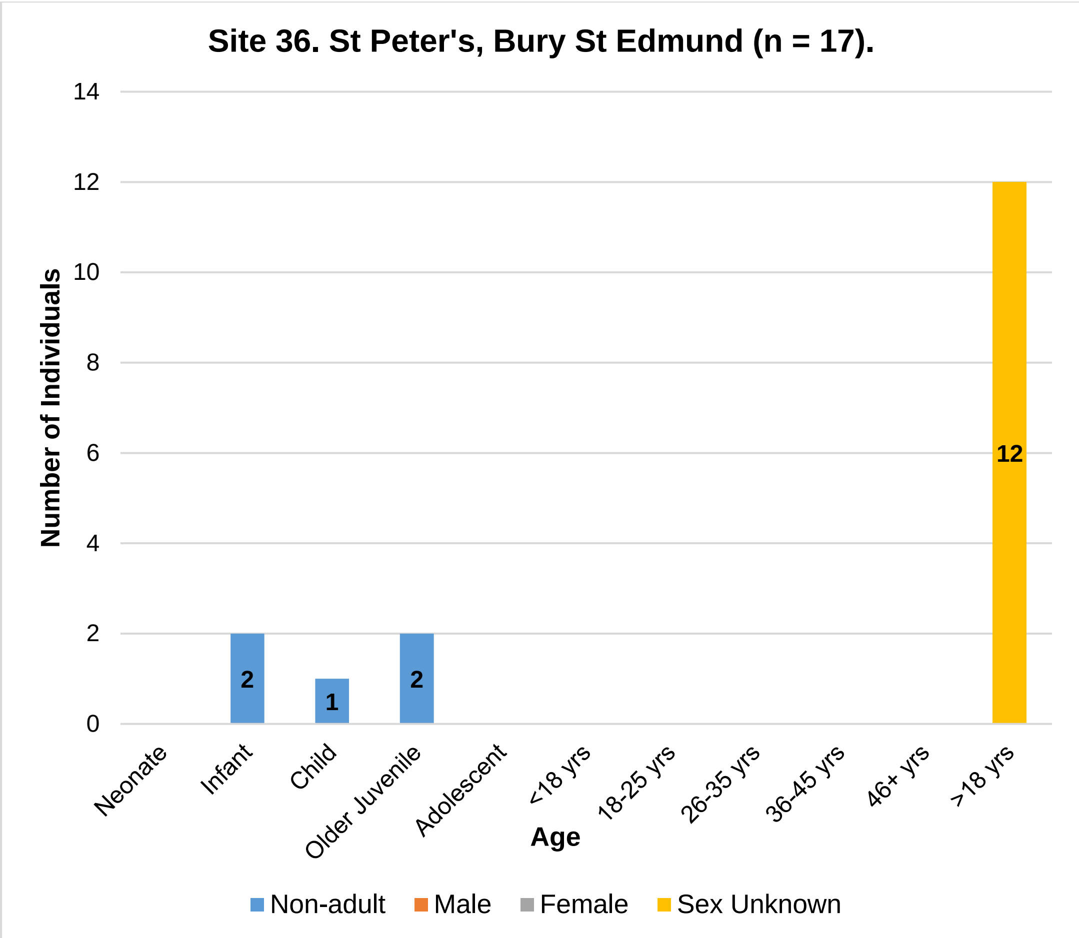
Founded: 1135 (for the use of priests with contagious diseases from 1301).

Dissolved: Post 1538.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 17. MNI analysed 5. Adult male: 0. Adult female: 0. Adult sex unknown: 12. Non-adult: 5. The site was excavated in two episodes, the first uncovered 12 adult individuals who were left *in situ* and not analysed. The second excavation in a neighbouring property uncovered five non-adult individuals who were analysed.

Reference: Brooks, 2012.



Site 37. St Saviour, Bury St Edmunds, Suffolk.

Hospital Type: A hospital for aged priests, later general hospital and then almshouse, dependent of Bury St Edmunds Abbey.

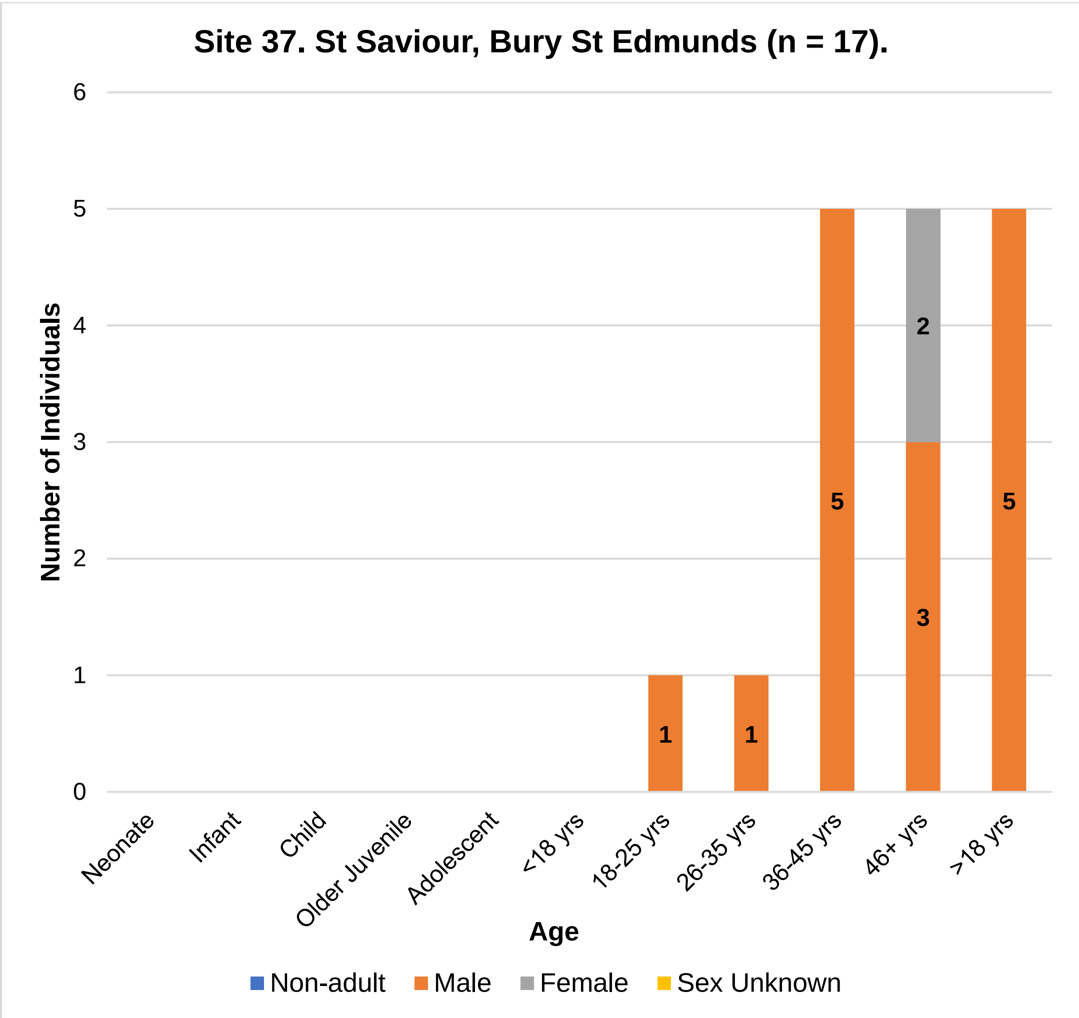
Founded: c.1184 (re-founded c.1290).

Dissolved: c.1539.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 17. Adult male: 15. Adult female: 2. Adult sex unknown: 0. Non-adult: 0.

Reference: Caruth and Anderson, 1997.



Site 38. St Leonard's, Coventry, Warwickshire.

Hospital Type: Leprosarium.

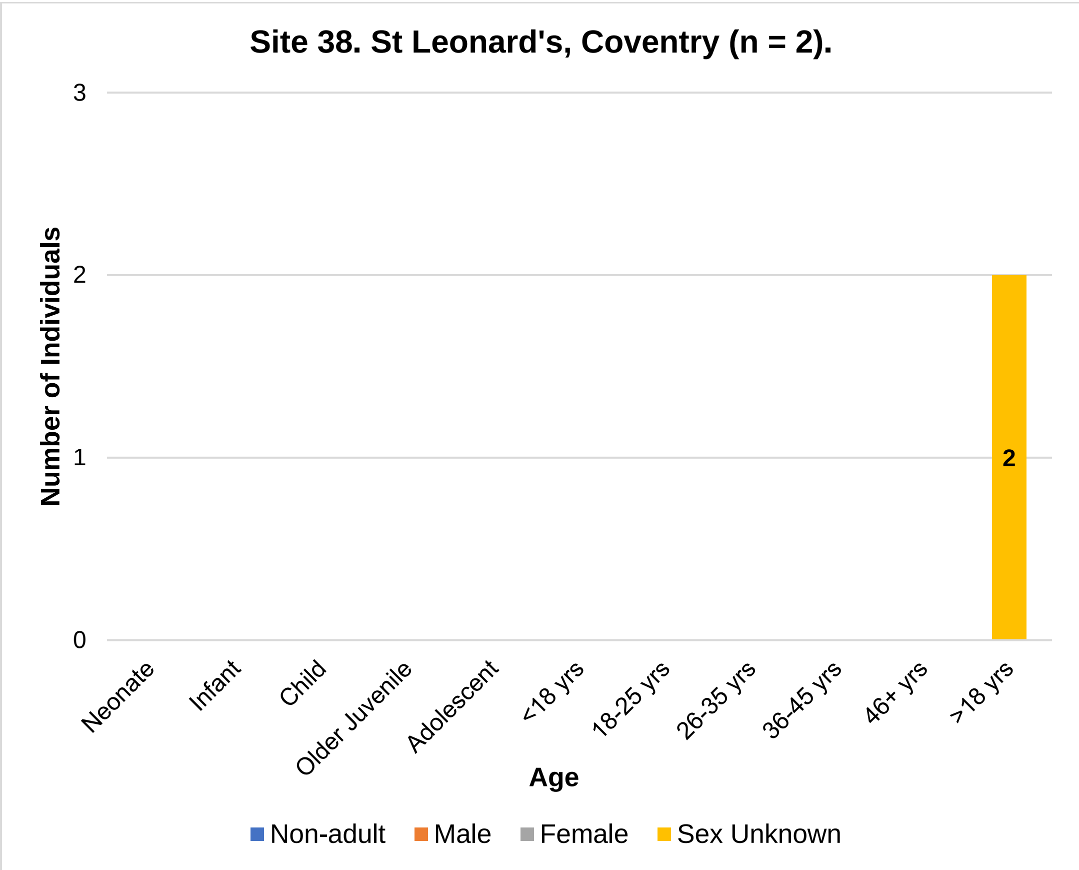
Founded: mid-12th C.

Dissolved: 1280.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 2. Adult male: 0. Adult female: 0. Adult sex unknown: 2. Non-adult: 0.

Reference: Palmer, 2007.



Site 39. St Mary Magdalen, Bidlington, West Sussex.

Hospital Type: Leprosarium and later almshouse.

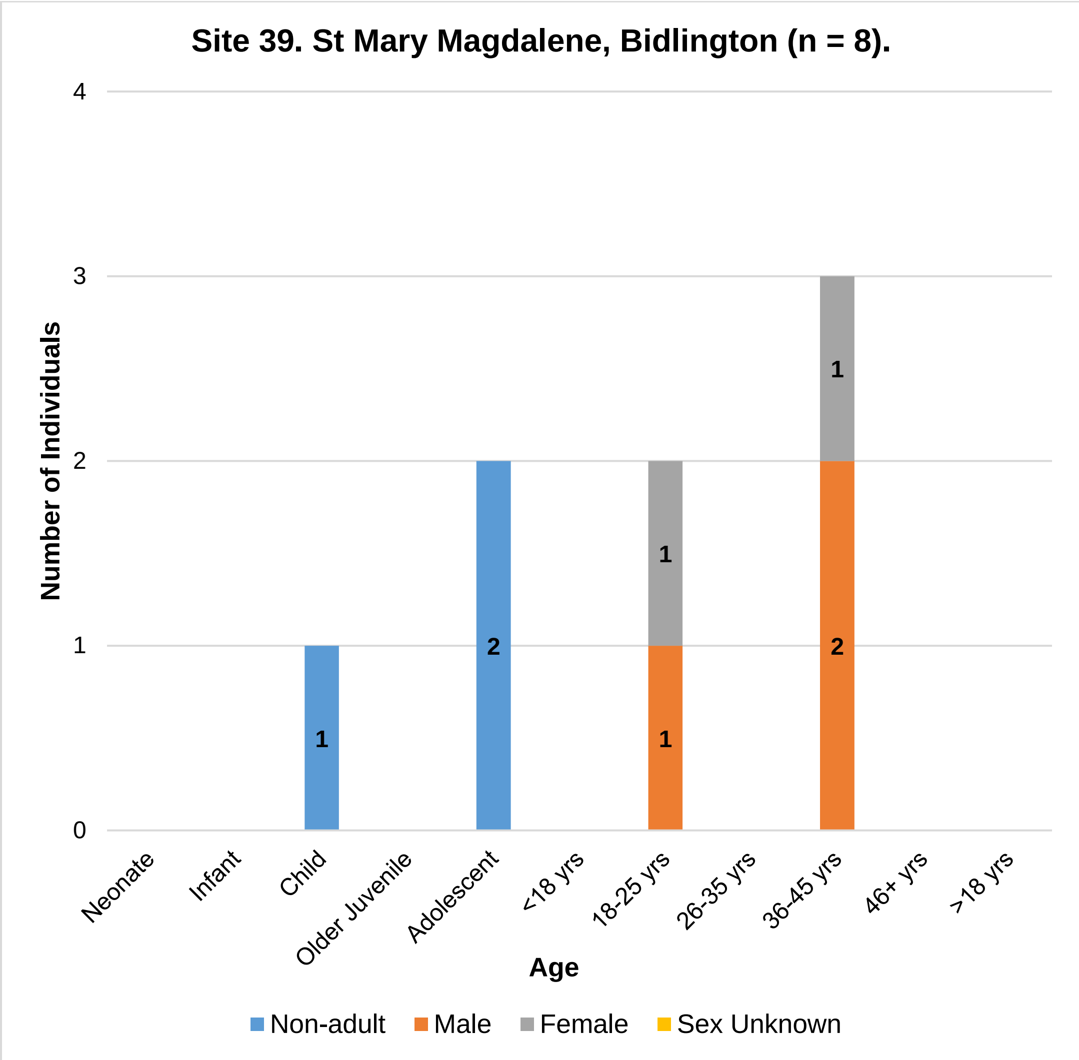
Founded: c.1216 (re-founded 1366 as an almshouse).

Dissolved: c.1535.

Date of Cemetery: Concurrent with the hospital?

Population: MNI 46. MNI analysed 8. Adult male: 3. Adult female: 2. Adult sex unknown: 0. Non-adult: 3.

Reference: Lewis, 1964.



Site 40. St James and St Mary Magdalene, Chichester, West Sussex.

Hospital Type: Leprosarium and later almshouse.

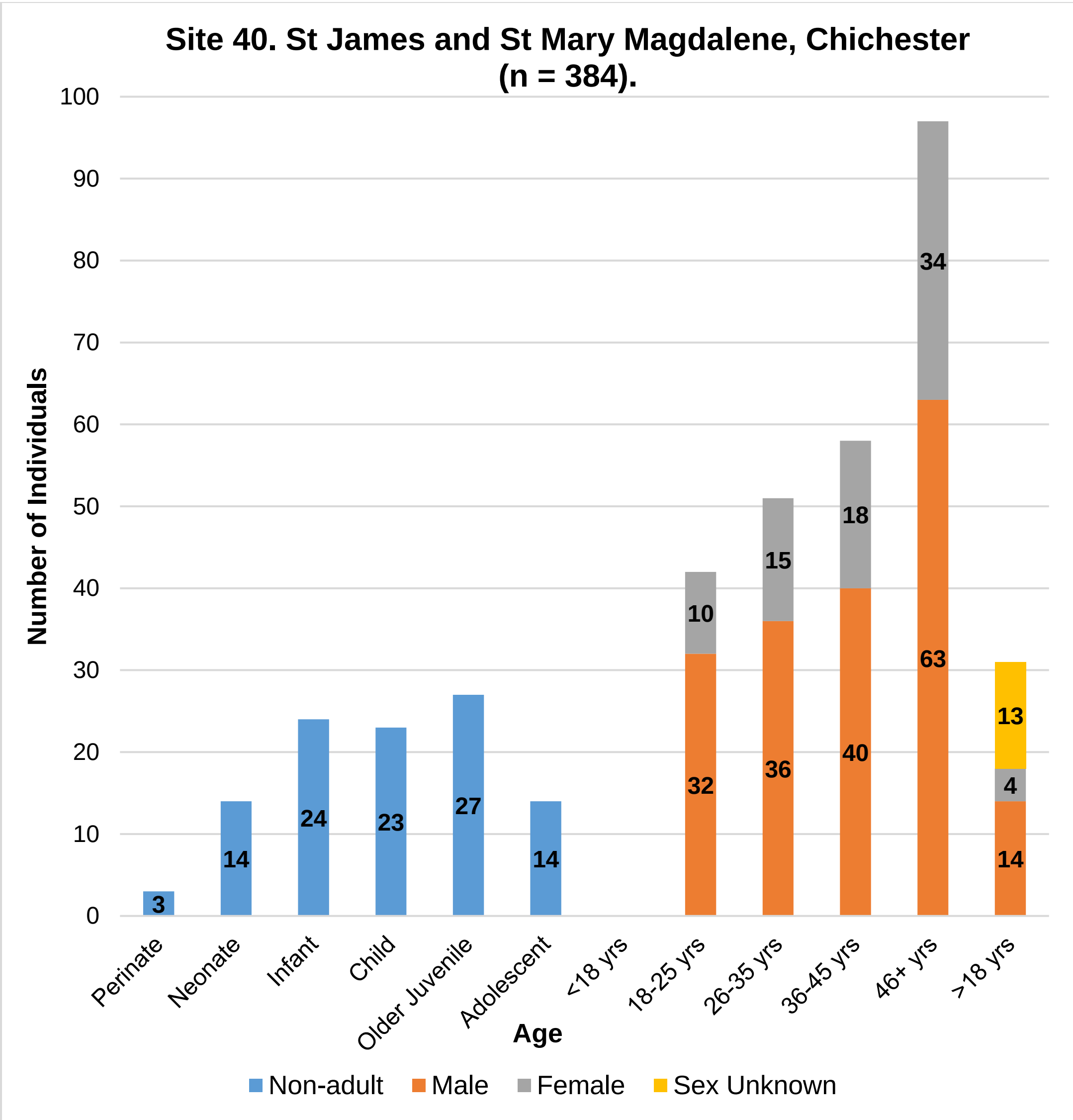
Founded: c.1118 (re-founded as almshouse c. 1442).

Dissolved: c.1621 (the almshouse continued into the 18th C. but struggled financially).

Date of Cemetery: Pre 13th C. - Post 16th C.?

Population: MNI 384. Adult male: 185. Adult female: 81. Adult sex unknown: 13. Non-adult: 105. Five adolescents were assessed as being probable males. High levels of coffin burials were identified.

Reference: Magilton *et al*., 2008.



Appendix 2: Glossary of Osteological Terms

The information in the glossary has been compiled from Marcovitch's (2010) *Black's Medical Dictionary*, Mays' (2010a) *The Archaeology of Human Bones*, Ortner's (2003) *Identification of Pathological Conditions in Human Skeletal Remains*, and relevant osteological reports used in this current research. The order of categories of terms listed in the glossary follows that used in the analysis of the data: congenital conditions, metabolic conditions, infectious disease, joint disease, miscellaneous, dentition, and trauma.

Congenital Conditions

Congenital Fusion: A condition in which two or more bones are permanently joined into one solid bone. This can occur with vertebrae and the phalanges of the foot.

Congenital Syphilis: A multistage infection caused by the spirochete *Treponema pallidum*. The disease is typically transmitted sexually although congenital infections can occur during pregnancy.

Cranial Anomalies: A term used to describe developmental disorders of the cranium, which can include excessive growth or tissue development, and premature or delayed closure of the cranial sutures.

Developmental Dysplasia of the Hip: An abnormal development of the hip joint, which can result in the dislocation of the femur. The condition can cause pain, difficulty walking, and osteoarthritis of the hip and back.

Klippel-Feil Syndrome: A rare skeletal disorder in which two or more of the cervical vertebrae are fused resulting in an abnormally short neck and restricted movement of the head.

Scoliosis: Curvature of the spine, consisting of a bend to one side and a rotary twist. It can result from disease or poor posture habits.

Spina Bifida Occulta: A condition caused by a deficit in the in the posterior part of the spinal column, this condition is generally asymptomatic and thought to affect approximately one in ten people.

Other Spinal Disorders: A term encompassing developmental anomalies of the spine which can be asymptomatic or cause compression or instability of the spinal column, including lumbarisation of the sacral vertebrae and kyphoscoliosis.

Spondylolysis: A term which incorporates disc degeneration and joint degeneration in the back. Osteoarthritis is often implicated. Pain is common in the neck and lumbar regions where the joints can become unstable.

Metabolic Conditions

Cribra Orbitalia: Pitting on the orbital roofs associated with anaemia.

Kidney Stone: Hard deposits formed by the crystallisation of minerals and salts inside the kidney which can cause severe pain.

Porotic Hyperostosis: Pitting on the cranial vault associated with anaemia.

Vitamin D deficiency Rickets: A childhood disease caused by a deficiency of vitamin D. It is mainly characterised by a softening of the bones with the leg bones bending outwards and forwards. Changes can occur in the cranial and axial bones, and teeth can erupt late and decay or fall out.

Vitamin C deficiency Scurvy: A disease caused by a deficiency of vitamin C. Symptoms include bleeding of the gums, loss of teeth, haemorrhage into joints, anaemia, lethargy, and depression.

Infectious Disease

Bowel Infection: Infections in the intestinal tract can be caused by different viral or bacterial diseases and parasites, resulting in inflammation or perforation of the bowel causing abdominal pain, vomiting, constipation, and diarrhoea. Chronic inflammatory infections can result in decreased bone density, and reduced bone formation and resorption.

Endocranial Lesions: Reactive new bone on part of the base of the skull, appearing as either diffuse or isolated layers of new bone on the cortical surface.

Fungal Infection: An infection caused by multicellular or unicellular fungi which typically infect the hair, skin, or nails. Some fungi can cause deep systemic infections.

Lamellar Bone: Mature bone comprised of a series of microscopic layers. By one year of age, most of the woven bone an infant is born with will be replaced by this stronger bone. Lamellar bone also forms later in life, as bone heals following a response to infection or injury.

Leprosy: A chronic bacterial infection caused by *Mycobacterium leprae*, affecting the nerves, skin, and mucous membranes. There are two clinical forms, tuberculoid which is usually benign, and lepromatous which is relentlessly progressive.

Advanced nerve damage can cause severe deformities, the loss of the extremities, and blindness.

Mastoiditis: Inflammation of the mastoid bone, located behind the ear, caused by a bacterial infection. It can develop following a persistent infection of the inner ear (otitis media).

Osteitis: Inflammation in the substance of a bone.

Osteolytic Lesions: Areas of damaged and softened bone caused by a decrease in bone remodelling due to a specific disease or tumour.

Osteomyelitis: Inflammation in the bone as a result of infection. The bacteria can remain dormant within the bone and repeat infections can occur at any time throughout the person's life.

Otitis Media: Inflammation of the middle ear, often caused by an infection in the nose, throat, or sinuses.

Otosclerosis: A condition in which abnormal bone is deposited around the middle ear, resulting in progressive conductive hearing loss.

Rhinitis: Inflammation of the mucous membrane of the nose.

Rib Lesions: An area of change or damage on the rib bone, often caused by a reaction to soft tissue inflammation due to lower respiratory tract infections such as chronic tuberculosis.

Sinusitis: A bacterial infection which usually follows a viral infection in the upper respiratory tract, causing inflammation in the mucosal lining of a sinus, typically the sinuses in the face, caused by infection spreading from the nasal passages.

Subperiosteal new bone formation: The deposition of new bone on the outer surface of bone in response to inflammation of the periosteum. The bone is initially laid down as woven bone, progressively developing into lamellar bone.

Treponemal Disease: A term used to describe the four infections (syphilis, yaws, bejel, and pinta) caused by the bacteria of the genus *Treponema*. The term includes **venereal syphilis,** a sexually transmitted disease which has three stages. In the primary stage an ulcer appears, followed by fever, loss of appetite, and bodily pains in the secondary stage. In the tertiary stage, gummas appear as hard nodules in the skin, forming tumour like masses in the muscles or producing thickening of the bone. They can develop in the brain and spinal cord, and later effects include aneurysm, stroke, general paralysis, and mental deterioration.

Tuberculosis: An infection caused by *Mycobacterium tuberculosis*, most commonly affecting the lungs, although most organs can be involved. Symptoms include fever, weight loss, coughing, and blood-stained sputum.

Woven Bone: Also known as fibre bone, it is the temporary tissue which forms the foetal skeleton. Woven bone is also produced later in life as an initial response to infection or trauma of the bone before remodelling into permanent lamellar bone.

Joint Disease

Ankylosis: A condition in which the movement of a joint is restricted by fibrous bands, by malformation, or by the union of the bones. This can be caused by an infectious disease.

Intervertebral Osteochondrosis: The degeneration of the intervertebral discs and the respective vertebral body endplates. A stage of spondylosis deformans, believed to be caused by normal aging.

Intervertebral Disc Disease: The degeneration with age of the fibrous disc which cushions the bony vertebrae. The disc can rupture or be displaced as a result of sudden strenuous activity.

Osteoarthritis: A joint problem caused by a change in the structure of cartilage or bone, which can cause the formation of bony outgrowths known as osteophytes.

Osteophytes: Bony spurs or projections, occurring most frequently at the margins of points involved in osteoarthritis.

Schmorl's Nodes: A type of spinal disc herniation involving the protrusion of the soft tissue of the intervertebral disc into the adjacent vertebrae. They often occur in the thoracic and lumbar spine and are thought to be caused by strenuous activity and spinal stress, possibly exacerbated by genetic factors.

Septic Arthritis: Infection of a joint which becomes warm, swollen, and sore with restricted movement. Without treatment the articular cartilage of the joint is destroyed, resulting in a painful, deformed, and sometimes immobile joint.

Spinal Degenerative Changes: A general term which can encompass normal deterioration of the spinal vertebrae caused by wear and aging.

Miscellaneous

Age Discrepancy: After birth, the use of dental development to determine the age of an individual is the most reliable osteological aging method. Average long bone lengths have been established for non-adults at differing ages although bone growth is affected by extrinsic factors. When these two methods of aging an induvial do not agree, then delayed skeletal growth is assumed.

Bone Cysts: A lesion, similar to a tumour or caused by infection or trauma, characterised by a fluid-filled cavity enclosed by a lining composed of connective tissue.

Chondroma: A tumour composed in part of cartilage.

Neoplastic Disorder: A disorder related to a tumour.

Osteochondroma: A common benign tumour appearing as a solitary lesion. It forms most often during childhood and is located most frequently near the growth plate of the metaphyseal surfaces of the long bones.

Osteoid Osteoma: A small, tumour like lesion consisting of poorly mineralised woven bone. It occurs most commonly in older children and young adults and is typically located on a long bone.

Torticollis: A shortness of the sternomastoid muscle on one side of the neck, resulting in asymmetry and limited movement of the neck.

Dentition

Abscess: A bacterial infection in or around a tooth which spreads to the bone, causing a localised collection of pus. Symptoms include inflammation, swelling, pain, and fever.

Calculus: An accumulation of bacterial plaque on the tooth surfaces which can mineralise and harden.

Caries: Dental decay initiated by bacteria producing acid from dietary carbohydrates, particularly refined sugar, which dissolves tooth enamel exposing the dentine to erosion. A hole develops at the site of decay and the tooth can collapse.

Dental Anomalies: Normal genetic based variations in the shape of teeth such as shovel shaped teeth, and other variations including the fusion of teeth and crowding.

Dental Enamel Hypoplasia: The temporary disruption of enamel formation caused by dietary deficiencies or disease, which results in recognisable pits or grooves on the enamel surface of teeth.

Periodontal Disease: Inflammation of the gingivae (gums) often caused by a bacterial infection, which results in secondary destruction of the underlying alveolar bone.

Trauma

Avulsion Injury: An injury which results in one tissue being torn away from another, from example a tendon could become detached from a bone.

Blunt Force Injury: A non-penetrating injury or trauma to the body caused by an impactful force with an object which is blunt as opposed to sharp.

Compression Fracture: A partial break in a bone caused by the crushing of trabecular bone. This is most commonly identified in the spinal column, following trauma or a weakening of the vertebrae.

Dental Trauma: An injury to the teeth which can have multiple causes such as a blow to the face, biting on hard materials, or abrasion of the teeth through the consumption of gritty materials.

Depressed Fracture: Most commonly found in skull fractures, a fragment of bone is forced inwards, below the level of the surrounding bone.

Fracture: A break in the continuity of the bone due to either violence or because the bone is unhealthy and unable to withstand normal stresses.

Green Stick Fracture: A fracture in young children whose bones are soft and bend rather than break in response to stress. The bone tends to buckle, and although these fractures heal quickly they can need treatment and support to avoid any deformity of the bone.

Healed Fracture: A break in the bone which has healed prior to death.

Muscle Trauma: An injury to the band of fibres which form muscle can occur for multiple reasons including repetitive strain, laceration, and contusion.

Oblique Fracture: A complete break in the bone caused by a combination of bending, twisting, and compression forces.

Osteochondritis Dissecans: The fragmentation and separation of a small segment of cartilage and possibly the underlying subchondral bone due to a lack of blood supply caused by repetitive trauma.

Osteochondroses Perthe's Disease: An affection of the hip due to the fragmentation of the epiphysis. It occurs in the age-group of 4 to 10 years and is more common in boys than in girls. It manifests initially with a lurching gait with a limp and pain. The condition can spontaneously recover in about two years.

Pathological Fracture: A fracture occurring in a bone which is already diseased.

Sharp Force Injury: Trauma that punctures or penetrates the skin caused by the impact of an object that is pointed, edged, or bevelled.

Soft Tissue Trauma: A range of impacts can cause damage to the skin and underlying soft tissue. These can be observable on the skeleton for example, through the observation of ossified haematomas.

Stress Fracture: Small cracks in a bone as a result of repetitive use or strain which impacts on the bone.

Supracondylar Fracture: A transverse or oblique break in the humerus, often caused by a fall onto an outstretched hand.

Transverse Fracture: A complete break in the bone caused by a force or blow at right angles to the long axis of a bone.

Unhealed Fracture: A break in a bone which has not healed prior to death. This can be due to the break occurring shortly before death, or the non-union of the bone as a result of complications.

Appendix 3: Questions and Hypotheses

The Pearson chi-square test and post-hoc z test were used to examine the hypotheses listed below.

Demography: Questions and Hypotheses

Question 1: Is there a difference in the proportion of non-adults by age category (younger juvenile, older juvenile, and adolescent) between the hospital locations (urban, marginal, and rural)?

H_0: There is no difference in the proportion of non-adults by age category across all locations of hospital sites.

H_1: There is a difference in the proportion of non-adults by age category across all locations of hospital sites.

Question 2: Is there a difference in the proportions of non-adults by age category (younger juvenile, older juvenile, and adolescent) in hospitals that did or did not cater for pilgrims?

H_0: There is no difference in the proportions of non-adults by age category in hospitals which did or did not cater for pilgrims.

H_1: There is a difference in the proportions of non-adults by age category in hospitals which did or did not cater for pilgrims.

Question 3: Where cemeteries have been phased, is there a difference in the proportions of non-adults by age category (younger juvenile, older juvenile, and adolescent) buried within each phase?

H_0: There is no difference in the proportions of non-adults by age category in hospital cemeteries by phase.

H_1: There is a difference in the proportions of non-adults by age category in hospital cemeteries by phase.

Disease: Questions and Hypotheses

Question 4: Is there a difference in the evidence for disease (congenital, metabolic, infectious, joint, miscellaneous, and dental) in non-adults by age category (younger juvenile, older juvenile, and adolescent)?

H_0: There is no difference in the evidence for disease in non-adults by age category.

H_1: There is a difference in the evidence for disease in non-adults by age category.

Question 5: Is there a difference in the evidence for disease (congenital, metabolic, infectious, joint, miscellaneous, and dental) in non-adults between the hospital site locations (urban, marginal, rural)?

H_0: There is no difference in the evidence for disease in non-adults across all hospital site locations.

H_1: There is a difference in the evidence for disease in non-adults across all hospital site locations.

General Stress Indicators: Questions and Hypotheses

Question 6: Is there a difference in the evidence for disease (congenital, metabolic, infectious, joint, miscellaneous, and dental) in non-adults who have a single general stress indicator compared to those who do not?

H_0: There is no difference in the evidence for disease in non-adults who have a general stress indicator and those who do not.

H_1: There is a difference in the evidence for disease in non-adults who have a general stress indicator and those who do not.

Question 7: Is there a difference in the evidence of multiple general stress indicators (cribra orbitalia, periosteal reaction, and dental enamel hypoplasia) in non-adults by age category (younger juvenile, older juvenile, and adolescent)?

H_0: There is no difference in the evidence of multiple general stress indicators in non-adults by age category.

H_1: There is a difference in the evidence of multiple general stress indicators in non-adults by age category.

Question 8: Is there a difference between the evidence for multiple general stress indicators (cribra orbitalia, subperiosteal new bone formation, and dental enamel hypoplasia) in non-adults between the locations of hospital sites (urban, marginal, and rural)?

H_0: There is no difference in the evidence of multiple general stress indicators in non-adults across all locations of hospital site.

H_1: There is a difference in the evidence of multiple general stress indicators in non-adults across all locations of hospital site.

Question 9: Are non-adults with multiple general stress indicators (cribra orbitalia, subperiosteal new bone formation, and dental enamel hypoplasia) more likely to have experienced disease (congenital, metabolic, infectious, joint, miscellaneous, or dental) than non-adults without general stress indicators?

H_0: There is no difference between non-adults with or without general stress indicators and the presence of disease.

H_1: There is a difference between non-adults with or without general stress indicators and the presence of disease.

Question 10: Are non-adults with or without one general stress indicator (cribra orbitalia, subperiosteal new bone formation, and dental enamel hypoplasia) more likely to have another general stress indicator?

H_0: There is no difference between non-adults with a general stress indicator and those without, and the presence of another general stress indicator.

H_1: There is a difference between non-adults with a general stress indicator and those without, and the presence of another general stress indicator.

Trauma: Questions and Hypotheses

Question 11: Is there a difference in the evidence for trauma in non-adults by age category (younger juvenile, older juvenile, and adolescent)?

H_0: There is no difference in the evidence for trauma in non-adults by age category.

H_1: There is a difference in the evidence for trauma in non-adults by age category.

Question 12: Is there a difference in the evidence for trauma in non-adults between the locations of hospital sites (urban, marginal, and rural)?

H_0: There is no difference in the evidence of trauma in non-adult individuals across all locations of hospital site.

H_1: There is a difference in the evidence of disease in non-adult individuals across all locations of hospital site.

Question 13: Is there a difference in the evidence of trauma in non-adults who had or had not, experienced disease (congenital, metabolic, infectious, joint, miscellaneous, and dental)?

H_0: There is no difference in the evidence of trauma in non-adults who had or had not, experienced disease.

H_1: There is a difference in the evidence of trauma in non-adults who had or had not, experienced disease.

Question 14: Is there a difference in the evidence of trauma in non-adults who exhibit general stress indicators (cribra orbitalia, subperiosteal new bone formation, and dental enamel hypoplasia) and those who do not?

H_0: There is no difference in the evidence of trauma in non-adults who exhibited general stress indicators and those who did not.

H_1: There is a difference in the evidence of trauma in non-adults who exhibited general stress indicators and those who did not.

Burial Practices: Questions and Hypotheses

Question 15: Is there a difference in the proportion of non-adults by age category (younger juvenile, older juvenile, and adolescent) and the use of coffin burials?

H_0: There is no difference in the proportion of non-adults by age category buried in coffins.

H_1: There is a difference in the proportion of non-adults by age category buried in coffins.

Question 16: Is there a difference between the evidence for the use of coffin burials for non-adults between the different hospital locations (urban, marginal, and rural)?

H_0: There is no difference in the evidence for the use of coffin burials for non-adults, between the different hospital locations.

H_1: There is a difference in the evidence for the use of coffin burials for non-adults, between the different hospital locations.

Question 17: Is there a difference in the evidence for leprosy reported in non-adults, and the use of coffins for burials?

H_0: There is no difference in the evidence for disease in non-adults and the use of coffins for burials.

H_1: There is a difference in the evidence for disease in non-adults and the use of coffins for burials.

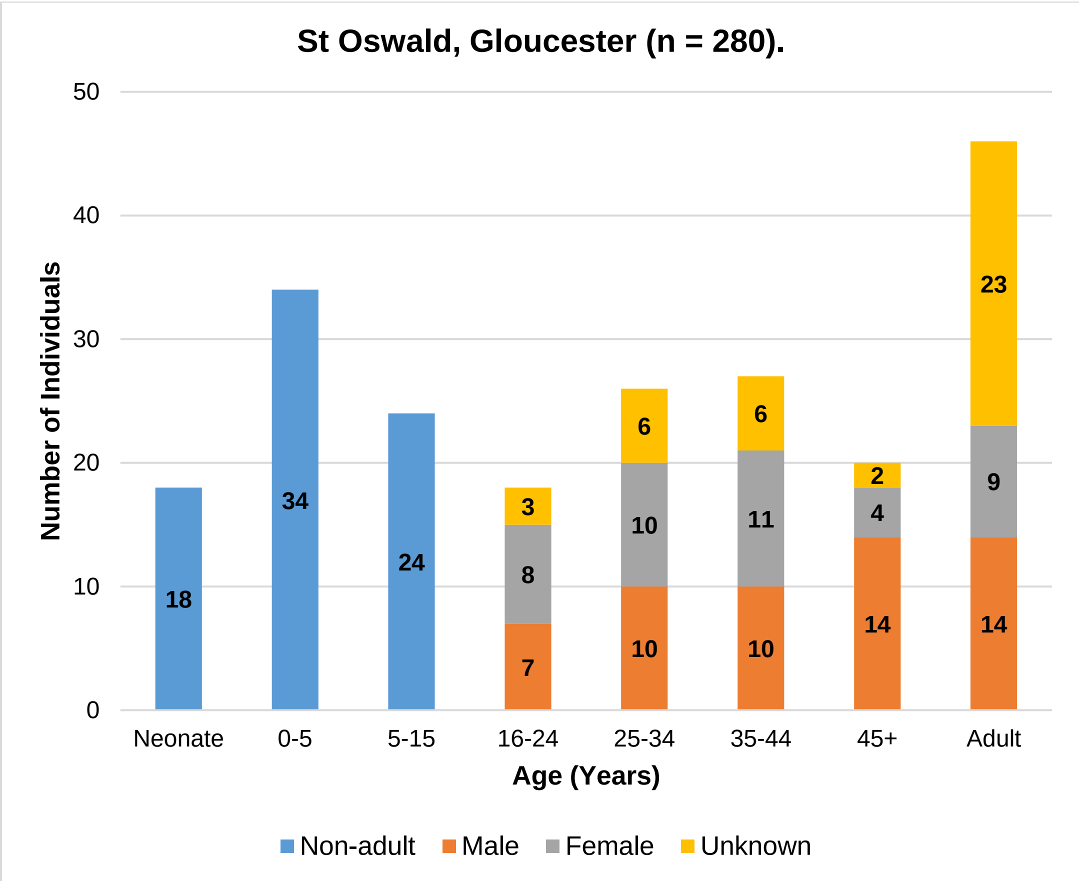
Appendix 4: Comparison Cemetery Sites

St Oswald, Gloucester, Gloucestershire.

Type of Cemetery: Rural priory and parish cemetery.

Date of Cemetery: 900-1855 (Norman and Medieval Periods c.1120-c.1540).

Population: MNI 600 from all periods (c.1120-c.1540 MNI = 280 including 76 non-adults).



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Sacralisation of the vertebra n = 3; Lumbarised vertebra n = 1
Metabolic	Porotic hyperostosis n = 5/48
Miscellaneous	Endocranial lesions n = 12/48
Dental	Caries n = 2/39

General Stress Indicators	
Cribra Orbitalia	n = 18/42
Subperiosteal new bone formation	n = 3
Dental Enamel Hypoplasia	n = 16/35

Trauma	
Kyphosis of the spine	n = 1

Burial Practices: Non-adult coffin burials n = 16. 'Ear-muffs' n = 1 and stone 'head-support' n = 1, both from the earlier phase. A possible double burial was identified of a neonate and an adult female.

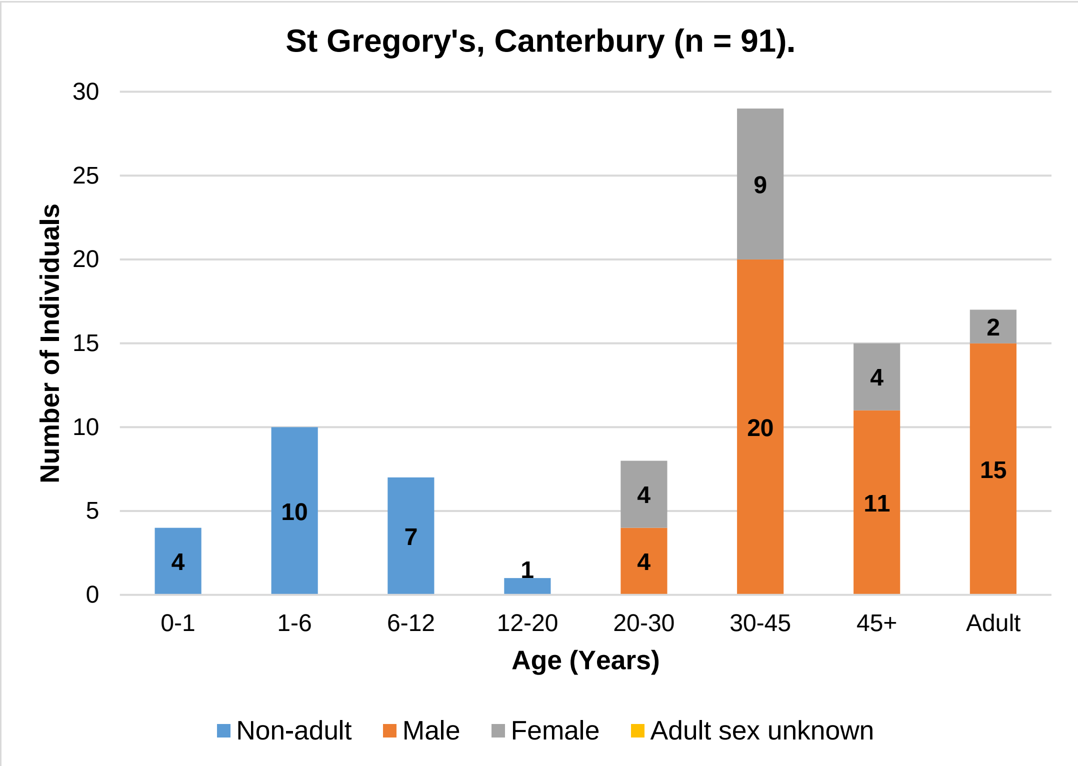
References: Heighway and Bryant, 1999; Dawson, 2014.

St Gregory, Canterbury, Kent.

Type of Cemetery: Priory and parish (inmates from the nearby hospital of St John the Baptist were also buried here).

Date of Cemetery: c.1080-1536.

Population: MNI 1,342. 91 individuals were osteologically analysed including 22 non-adults. Further analysis by Dawson (2014) analysed 104 non-adults comprising seven neonates, 15 0-2 year olds, 57 2-7 year olds, and 25 7-12 year olds.



Non-adult Pathologies and Trauma:

Pathology	
Infection	Tuberculosis n = 1
Miscellaneous	Endocranial lesions n = 4/85
Dental	Caries n = 15/96; Calculus n = 5/15

General Stress Indicators	
Cribra Orbitalia	n = 28/63
Subperiosteal new bone formation	n = 23/61
Dental Enamel Hypoplasia	n = 24/92

Burial Practices: Two double burials were identified, one containing two non-adults, a 2-3 year old and a 3-5 year old, and another containing two adults. Four non-adults were buried within the church and were likely to be family members of lay benefactors.

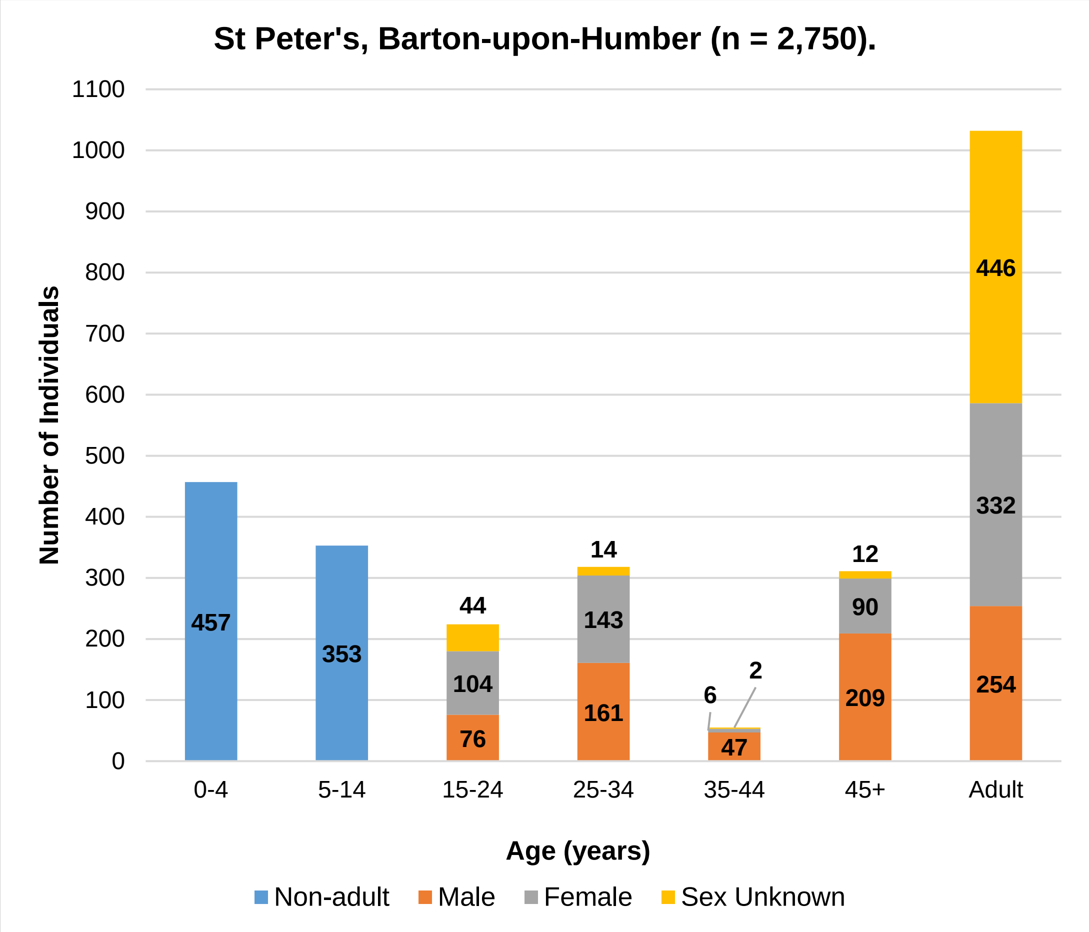
References: Hicks and Hicks, 2001; Dawson, 2014.

St Peter's Church, Barton-upon-Humber, Lincolnshire.

Type of Cemetery: Market town, parish church.

Date of Cemetery: 950-1855 (earliest three phases E, D, and C, 950-1500).

Population: MNI 2,750 including 810 non-adults.



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Bifid sacrum n = 1
Metabolic	Vitamin D deficiency rickets n = 3
Infection	Osteomyelitis n = 5; Septic arthritis n = 1;
Joint	Schmorl's nodes n = 4

General Stress Indicators (from total non-adult population)	
Cribra Orbitalia	n = 87
Subperiosteal new bone formation	n = 47
Dental Enamel Hypoplasia	n = 10

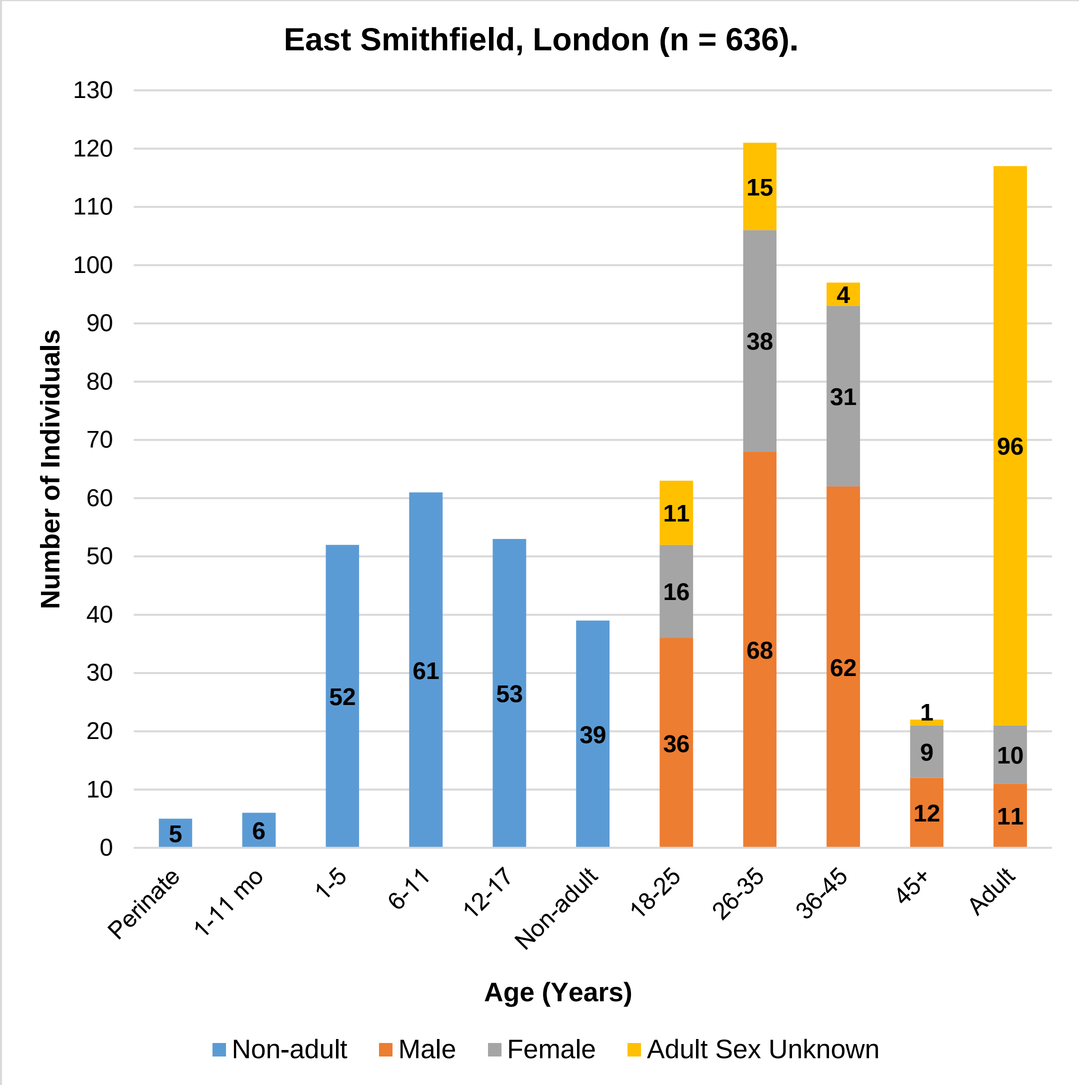
Trauma	
Cranial Fracture	n = 2
Post-cranial Injury	n = 1

Burial Practices: Several multiple burials were identified including a multiple burial of two adult males and three children, a double burial of two older children, multiple burials consisting of an adult and a baby, and a triple burial of an adult with two infants. Three instances of adult females buried with a foetus *in situ* dating to the medieval period were also identified.

Reference: Waldron, 2007.

East Smithfield, London.

Type of Cemetery: Black Death Cemetery.
Date of Cemetery: 1348-1350.
Population: MNI 636 including 177 non-adults.



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Limb abnormality n = 4
Metabolic	Vitamin D deficiency rickets n = 1
Infection	Treponematosis n = 1; Tuberculosis n = 2
Joint	Osteochondritis dissecans n = 2
Dental	Caries n = 21/108; Calculus n = 54/108; Periodontitis n = 5/98; Abscess n = 2/98
Miscellaneous	Osteochondroma n = 2

General Stress Indicators	
Cribra Orbitalia	Left n = 22, Right n = 23
Subperiosteal new bone formation	n = 9
Dental Enamel Hypoplasia	n = 38/108

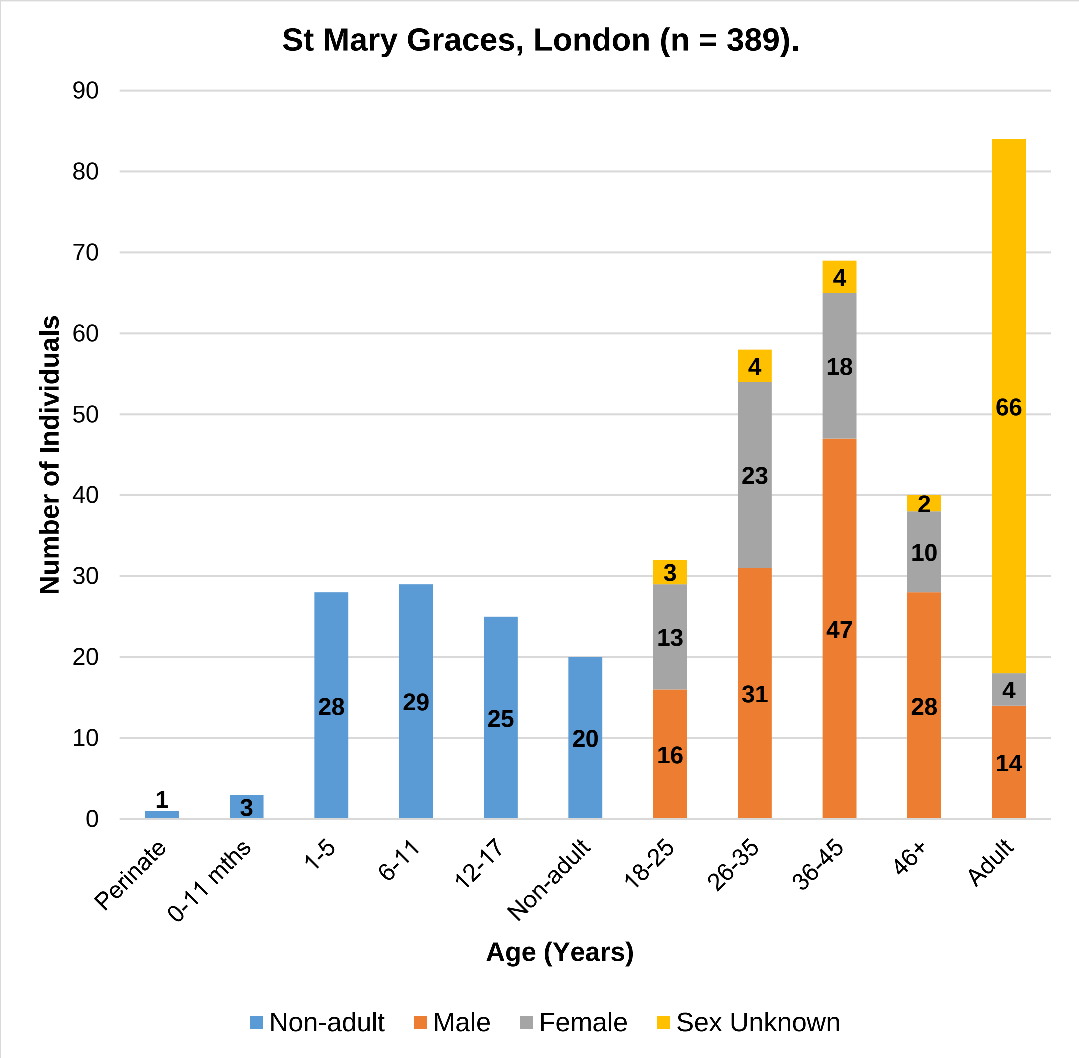
Trauma	
Healed fracture	n = 2
Soft tissue trauma	n = 2

Burial Practices: 268 individuals were buried in individual graves in 11 rows, and 398 were buried within three mass graves. Non-adults accounted for 29% of the individuals buried in rows, and 41.5%, 38%, and 39%, respectively, from the three mass graves. Although not statistically significant, neonates and infants formed a higher proportion in the individual rows of burials, whereas adolescents accounted for a lower proportion. There was a prevalence of older children within the mass graves with an almost complete absence of neonates and infants.

Reference: Cowal *et al*. 2008.

St Mary Graces, London.

Type of Cemetery: Cemetery of the Cistercian abbey of St Mary Graces.
Date of Cemetery: 1350-1540.
Population: MNI 389 including 106 non-adults.



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Other n = 3; Spondylolysis n = 1
Metabolic	Porotic hyperostosis n = 1; Vitamin C deficiency scurvy n = 3; Vitamin D deficiency rickets n = 1
Infection	Tuberculosis n = 2
Dental	Caries n = 8/57; Calculus n = 14/57; Periodontitis n = 2/57; Abscess n = 2/57
Miscellaneous	Osteochondroma n = 1;

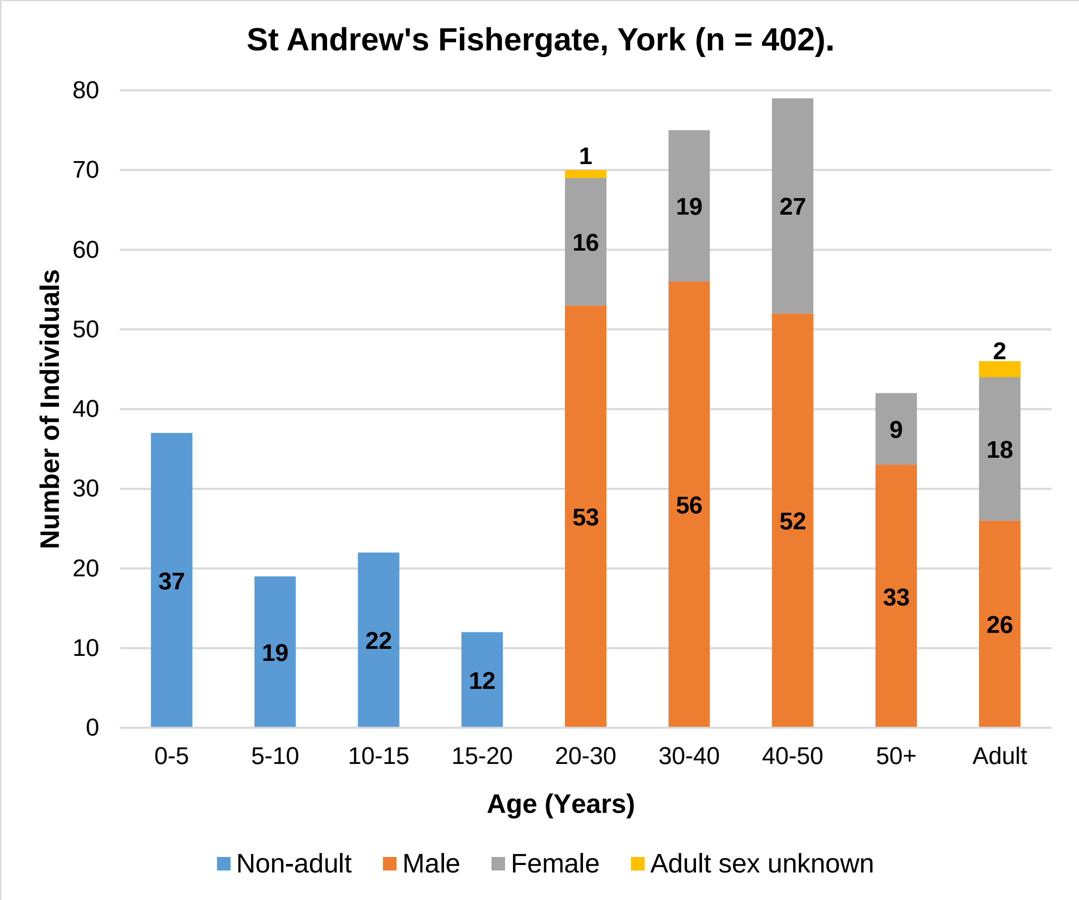
General Stress Indicators	
Cribra Orbitalia	Left n = 14, Right n = 13
Subperiosteal new bone formation	n = 11
Dental Enamel Hypoplasia	n = 12/57

Trauma	
Soft tissue trauma	n = 1
Osteochondritis dissecans	n = 1

Reference: Bekvalac *et al*. 2007.

St Andrew Fishergate, York, North Yorkshire.

Type of Cemetery: Parish and later priory.
Date of Cemetery: 1050-1350.
Population: MNI 402 including 90 non-adults.



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Spondylolysis n = 1
Infection	Tuberculosis n = 2?
Dental	Caries n = 8/42; Abscess n = 2/40

General Stress Indicators	
Cribra Orbitalia	n = 16/25
Subperiosteal new bone formation	n = 5
Dental Enamel Hypoplasia	25% of <20 year olds had at least three lines on their teeth associated with DEH

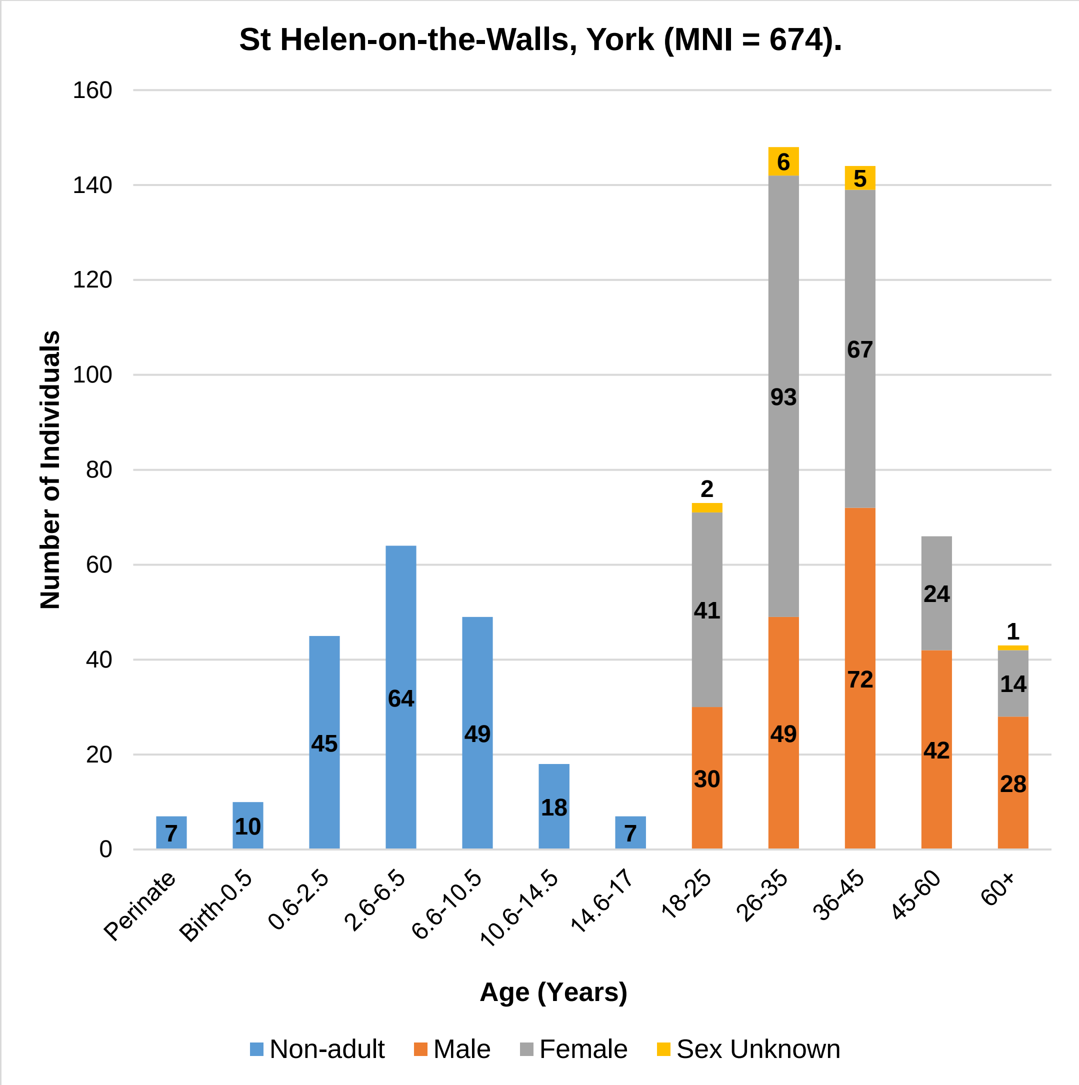
Reference: Stroud and Kemp, 1993.

St Helen-on-the-Walls, York, North Yorkshire.

Type of Cemetery: Urban parish.

Date of Cemetery: 950 - 1550.

Population: MNI 1,041 including 317 non-adults. MNI with known age and sex = 674 including 200 non-adults.



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Bifid rib n = 1
Metabolic	Vitamin D deficiency rickets n = 1; Vitamin C deficiency scurvy n = 2
Infection	Sinusitis n = 6; Tuberculosis n = 2; Ringworm n = 1; Non-specific infection n = 5
Dental	Caries and abscess n = 18/83

General Stress Indicators	
Cribra Orbitalia	n = 56/87
Subperiosteal new bone formation	n = 20/104
Dental Enamel Hypoplasia	n = 34/92

Trauma	
Fractures	n = 3
Other	Haematoma n = 1

Burial Practices: There was limited evidence for a clustering of burials of children and young adults in the southern corner of the cemetery. Infants are under-represented and may have been buried in the area of the cemetery which was not excavated. Several examples existed of females buried in a joint interment with a neonate, and 'most' infants recovered had been buried with an adult (Dawes, 1980: 27). A double burial of two older children was identified.

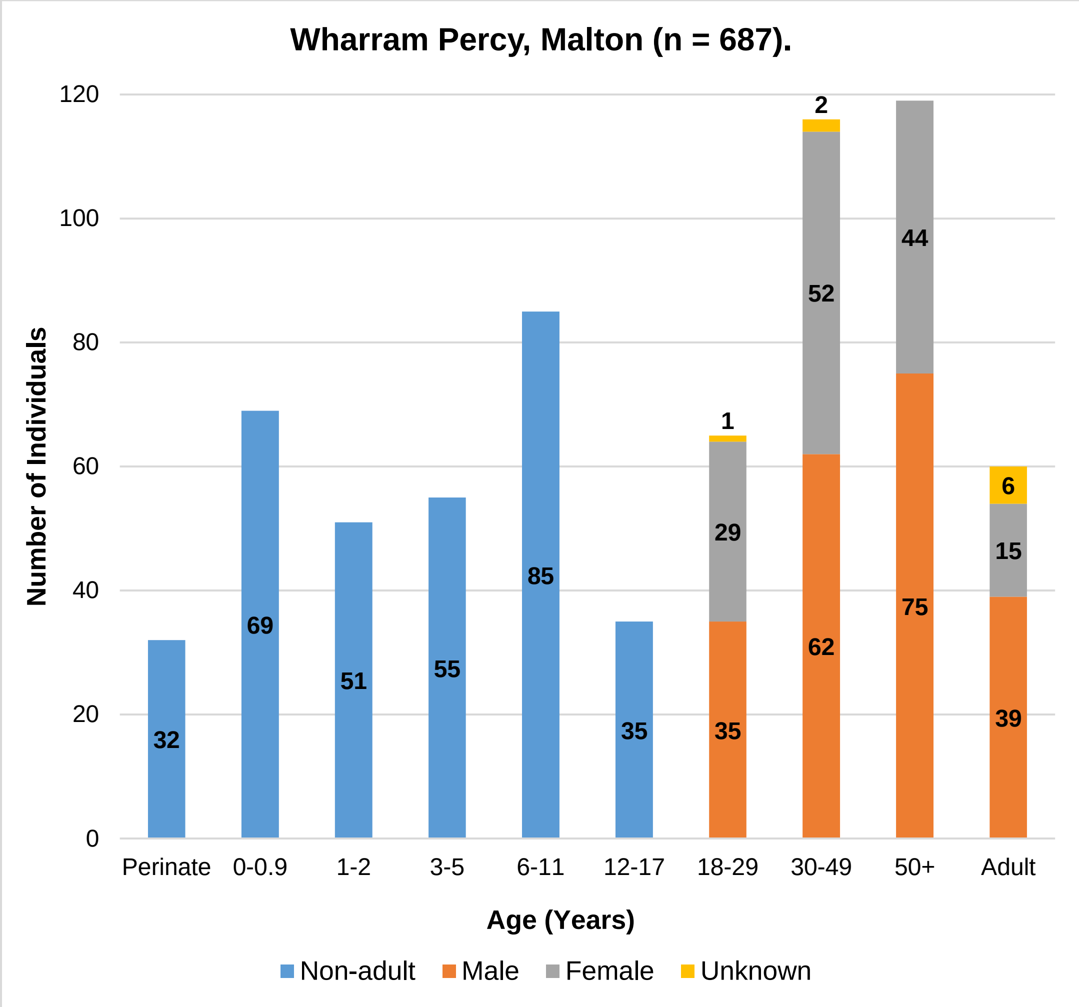
References: Dawes and Magilton 1980; Lewis 2002b.

Wharram Percy, Malton, North Yorkshire.

Type of Cemetery: Rural parish.

Date of Cemetery: 950 - 1850 (Phase 2 - 3, 1066 - 1540).

Population: MNI 687 including 327 non-adults.



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Spondylolysis n = 2; Spina bifida occulta n = 8; Klippel-Feil n = 1
Metabolic	Vitamin D deficiency rickets n = 8
Infection	Leprosy n = 1
Dental	Caries n = 31/194; Abscess n = 6/190; Calculus n = 43/188

General Stress Indicators	
Cribra Orbitalia	n = 76/247
Subperiosteal new bone formation	n = 29
Dental Enamel Hypoplasia	n = 24/94

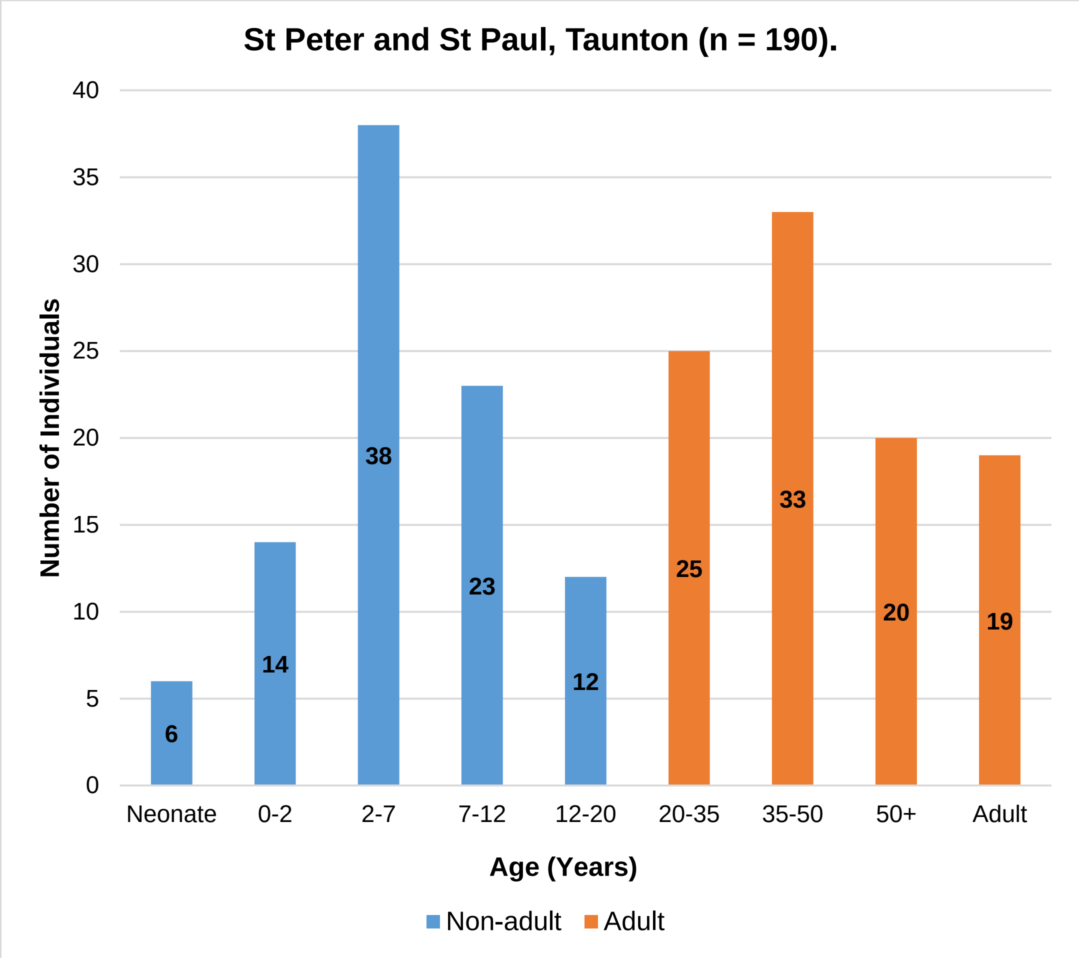
Trauma	
Dental trauma	n = 2
Fracture	n = 2
Osteochondritis dissecans	n = 1

Burial Practices: Eight double burials were identified, five were of an adult and non-adult, three contained two non-adults. Coffin use was identified for 12/327 (3.7%) non-adults, and 22/360 (6.1%) adults.

Reference: Mays, 2007.

St Peter and St Paul, Taunton, Somerset.

Type of Cemetery: Priory and lay persons.
Date of Cemetery: c.1150 - c.1535.
Population: MNI 190 including 93 non-adults (97 adults: male = 60, female = 29).



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Bifurcated rib n = 1
Infection	Tuberculosis n = 1
Dental	Caries n = 22/65

General Stress Indicators	
Cribra Orbitalia	n = 26/50
Subperiosteal new bone formation	n = 30
Dental Enamel Hypoplasia	n = 29/63

Trauma	
Greenstick Fracture	n = 1

Burial Practices: Three double burials were identified, one containing two nine year olds placed with their hands together, another containing a five and a ten year old with their hands together, and a third containing a seven and an eight year old. Two non-adults were buried in coffins, one of whom was buried within the church.

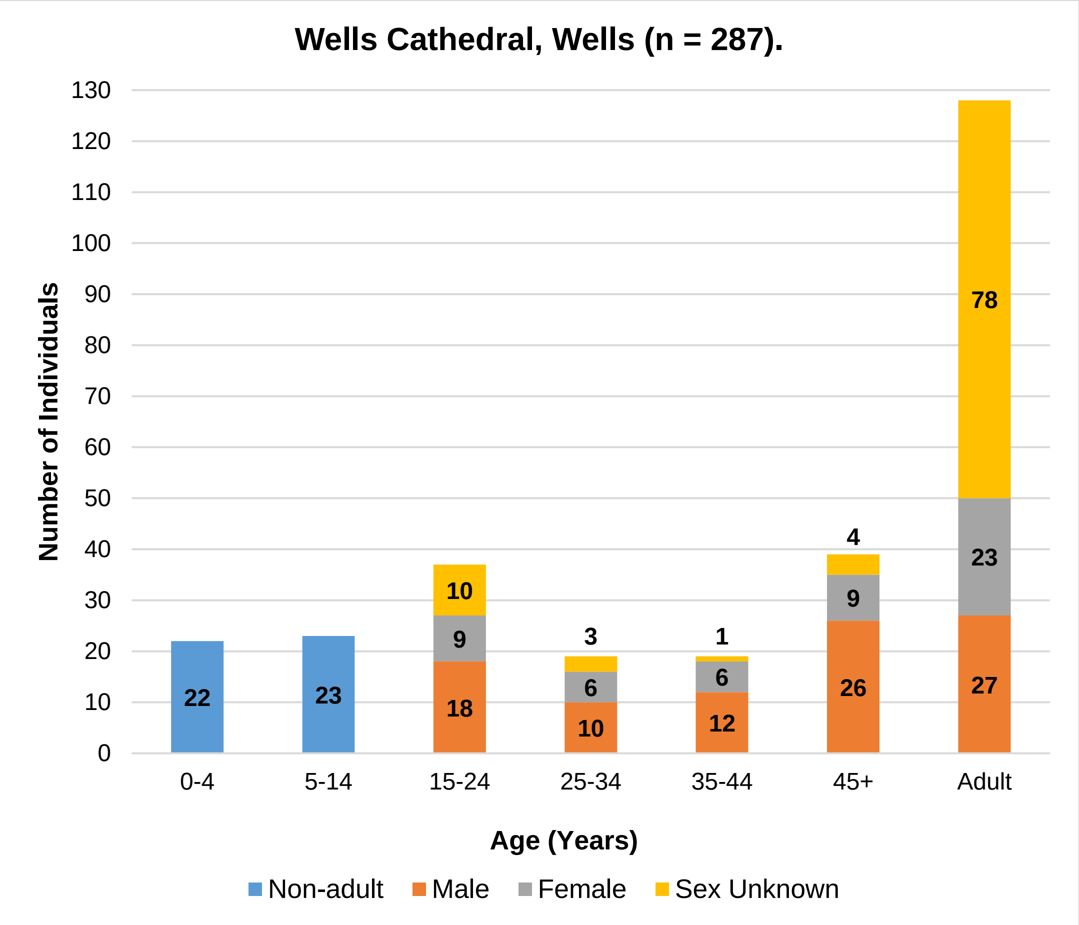
Reference: Dawson, 2014.

Wells Cathedral, Wells, Somerset.

Type of Cemetery: Cathedral chapel and cemetery burials.

Date of Cemetery: Early medieval - 1550.

Population: MNI 287 including 45 non-adults (28 adults and 6 non-adults dated to the Anglo-Saxon period).



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Tibial dysplasia n = 1
Infection	Caffey's disease n = 1

General Stress Indicators	
Cribra Orbitalia	n = 2
Subperiosteal new bone formation	n = 1
Dental Enamel Hypoplasia	Data not published separately for non-adults

Burial Practices: Three non-adults were buried in a cist, three in a coffin, one with a stone coffin and cover, and three with a stone cover. One non-adult was buried in a reversed orientation.

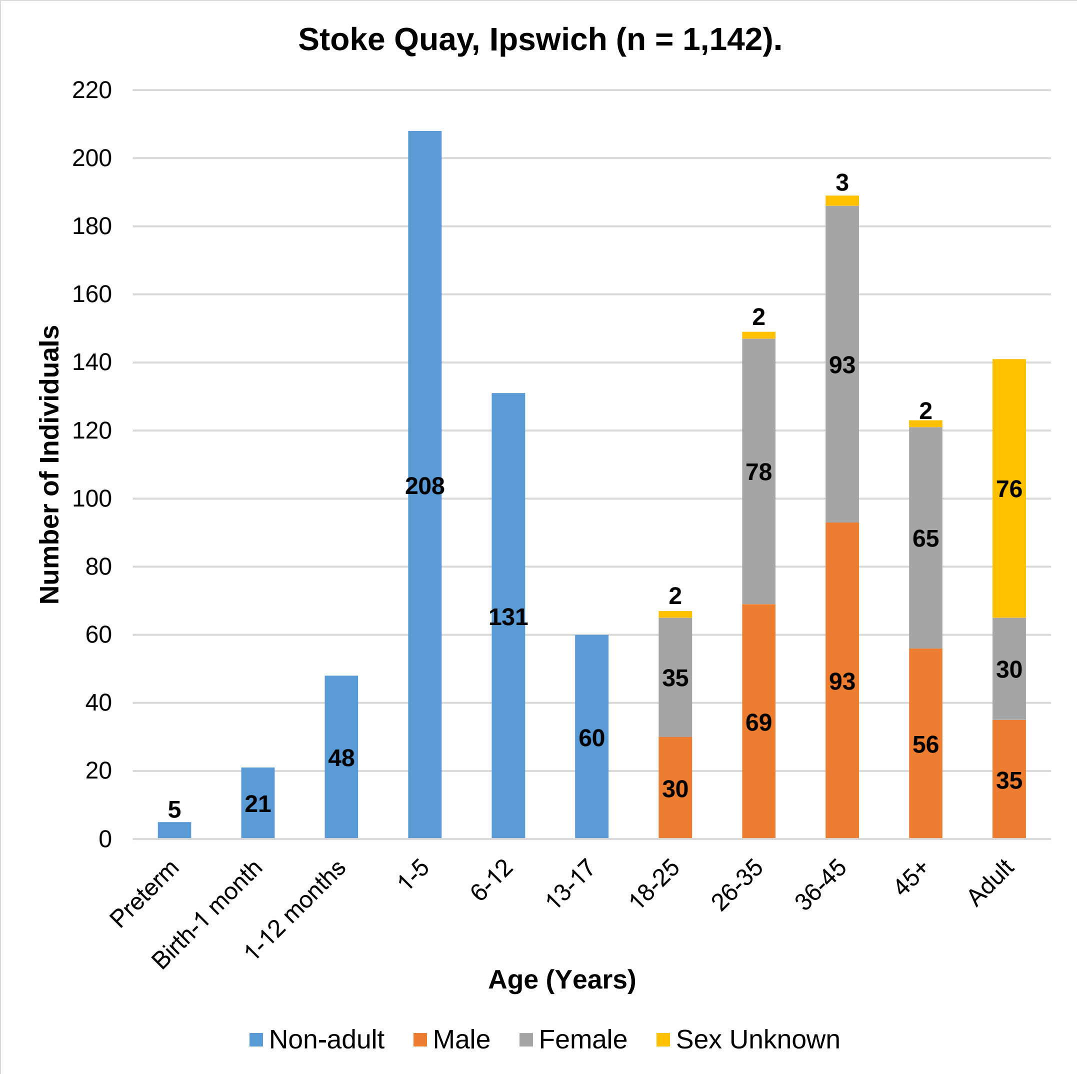
Reference: Rogers, 2001.

Stoke Quay, Ipswich, Suffolk.

Type of Cemetery: Parish church.

Date of Cemetery: Late 9th – Late 15th centuries (Periods 5 and 6, Late 11th – Late 15th centuries).

Population: MNI 1,142 including 473 non-adults.



Non-adult Pathologies and Trauma:

Pathology	
Congenital	Skull abnormality n = 2; Rib abnormality n = 5; Spina bifida occulta n = 2; Spondylolysis n = 3; Klippel-Feil syndrome n = 3; Spinal abnormality n = 21; Congenital syphilis n = 2
Metabolic	Porotic hyperostosis n = 2; Vitamin D deficiency rickets n = 2; Vitamin C deficiency scurvy n = 25
Infection	Sinusitis n = 17; Tuberculosis n = 5
Joint	Schmorl's nodes n = 6
Dental (TPR)	Calculus 1,208/5,412; Caries 131/5,412; Abscess 17/9,859
Miscellaneous	Endocranial lesions n = 73

General Stress Indicators	
Cribra Orbitalia	n = 203
Subperiosteal new bone formation	n = 92
Dental Enamel Hypoplasia (TPR)	547/5,279

Trauma	
Fractures	n = 6
Osteochondritis Dissecans	n = 8
Sharp force trauma	n = 1

Burial Practices: Coffin use was identified in Period 5 (infant n = 13 and child n = 40, 45.3%) and in Period 6 (infant n = 3 and child n = 15, 25.7%). A possible copper alloy finger-ring was recovered from the grave of a neonate.

Reference: Gibson *et al*. 2020.