Archives of Oral Biology 63 (2016) 32–39

Contents lists available at ScienceDirect

Archives of Oral Biology

journal homepage: www.elsevier.com/locate/aob

# Sex differentials in caries frequencies in Medieval London

Brittany S. Walter[a,*], Sharon N. DeWitte[a], Rebecca C. Redfern[b]

[a] Department of Anthropology, University of South Carolina, Columbia, SC 29208, United States
[b] Centre for Human Bioarchaeology, Museum of London, 150 London Wall, London EC2Y 5HN, United Kingdom

ARTICLE INFO

*Article history:*
Received 5 August 2015
Received in revised form 13 October 2015
Accepted 29 November 2015

*Keywords:*
Caries
Sex differentials
Oral health
Medieval London

ABSTRACT

*Objective:* Tooth decay is one of the most common oral infections observed in skeletal assemblages. Sex differentials in caries frequency are commonly examined, with most studies finding that females tend to have a higher frequency of carious lesions (caries) compared to males. Less research has examined differences in caries between males and females with respect to age in past populations. Findings from living populations indicate that caries frequencies are higher in females, at least in part, because of the effects of estrogen and pregnancy. We are interested in the interaction of age, sex, and caries in medieval London, during a period of repeated famines, which might have exacerbated underlying biological causes of caries sex differentials.
*Design:* We examined caries in adults from two medieval London cemeteries dating to *c.* 1120–1539 AD: St. Mary Spital ($n = 291$) and St. Mary Graces ($n = 80$) to test the hypothesis that males and females have different caries frequencies irrespective of age. The association between maxillary molar caries and sex was tested using hierarchical log-linear analysis to control for the effects of age on caries frequencies.
*Results:* The results indicate a higher frequency of maxillary molar caries in females ($P < 0.00$), and that the age distribution of caries differs between the sexes ($P = 0.01$), with a consistent increase in frequency with age for females until late adulthood, but not males.
*Conclusions:* The difference in caries frequencies is not explained by differences in the age distributions of the sexes. Differences in the age patterns of caries for males and females could be the result of biological factors that present during reproductive age, differences in diet, or differential access to resources during famine.



## 1. Introduction

Tooth decay is one of the most common oral infections observed in both present day populations and bioarchaeological assemblages. Dental cariogenesis, commonly known as cavity formation, is the process by which focal demineralization of dental tissue occurs as a result of the activity of acidogenic bacteria in plaque; this process usually initially affects the enamel of the tooth and, subsequently, the underlying dentin (Featherstone, 2000). Teeth are often recorded and analyzed in bioarchaeological and paleopathological investigations because they are highly mineralized, making them more resistant to taphonomic factors, unlike bone tissue, which is less durable and highly susceptible to environmental changes after interment (Roberts & Cox, 2003). With the substantial quantity of teeth available in the archaeological record, dental health has been used as a proxy measure of general health levels in past populations in addition to diet, oral hygiene and other factors.

As with many other diseases (e.g., periodontal disease, cardiovascular disease, certain cancers, and autoimmune disorders), there is a difference between the sexes in the risk of developing carious lesions (hereafter referred to as caries). In both living and past populations, females tend to have a higher frequency of caries compared to males (Lukacs, 2008; Lukacs & Thompson, 2008; Roberts & Cox, 2003; Saunders, De Vito, & Katzenberg, 1997; Wasterlain, Hillson, & Cunha, 2009; Whittaker & Molleson, 1996). Findings from living populations indicate that caries frequencies are higher in females because of the complex effects of biological and behavioral differences between the sexes. Clinical literature attributes higher caries presence in females to physiological sex differences that have an indirect, though

* Corresponding author at: Department of Anthropology, 817 Henderson Street, Gambrell Hall Room 440A, University of South Carolina, SC 29208, United States. Fax: +1 803 777 0259.
*E-mail address:* walterbs@email.sc.edu (B.S. Walter).

http://dx.doi.org/10.1016/j.archoralbio.2015.11.024
0003-9969/

important, influence on dental health and oral ecology. Specifically, saliva type and quantity, higher estrogen levels, and hormonal fluctuation have been associated with an adverse impact on women's oral health, and thus caries rates (Lukacs, 2011b). Behavioral differences resulting from sexual division of labor have also been linked to increased rates of caries in females (Kelley, Levesque, & Weidl, 1991; Larsen, Shavit, & Griffin, 1991; Temple & Larsen, 2007). For example, in some cultures, males who are responsible for acquiring meat may be exposed to less cariogenic foods, compared to females who spend a majority of their time caring for and gathering cariogenic plants (Walker & Hewlett, 1990). Here, we examine sex differences in caries in medieval London to gain insights into the differential experiences of males and females during a period of important and wide-ranging demographic crises (e.g., famine and plague epidemics).

Diet is an important factor to consider when exploring oral health, particularly dental caries, as food intake has a substantial effect on the etiology of caries (Rugg-Gunn & Hackett, 1993). For medieval London, we are fortunate to have a range of archaeological (i.e., faunal bones and pottery) and primary source evidence (i.e., household accounts) to understand diet in this period (Woolgar, Serjeantson, & Waldron, 2006). As is true today, medieval London drew on a vast hinterland to supply it with produce, animals, vegetables and cereals being brought into the city from the market gardens in the suburbs or further-afield (Galloway & Murphy, 1991). Its riverside location meant that fish (fresh or cured) were brought in via shipping from the English coast and continental Europe. Combined with the archaeological evidence for food preparation, cooking and storage, it is well-established that London had diverse food-ways, and was unique in England because of its access to a variety of local and exotic foods, reflecting the diversity of communities living in the city. This evidence also reveals that diets differed according to social status, with religious orders and higher status individuals (i.e., merchants) consuming higher quantities of meat and fish, with lower status people consuming what has been termed a 'rural diet' or a 'peasant diet' because it contained very low or no animal or fish protein and was mostly vegetable and cereal based (e.g., pottages) (Dyer, 1989).

In addition to archaeological and documentary evidence, there is limited isotopic data on diet in medieval London. To date, only one study has investigated dietary stable isotope values in medieval London (Lakin, 2008). This study, using rib samples from two medieval sites in London (St. Mary Spital and St. Nicholas Shambles) found that, in contrast to York (Müldner & Richards, 2007), there was considerable dietary heterogeneity in London, confirming the existing documentary and archaeological evidence. Lakin (2008) also identified two individuals who likely consumed a 'rural diet', as their dietary values matched the sampled faunal values. In contrast to the other sources of evidence, this study demonstrated that there were no statistically significant differences in isotope values among adult age groups (>18 years old). However, the majority of 18–25 year old females had more negative $\delta^{13}N$ values compared to older females. Lakin (2008) suggests that this may reflect a number of factors: pregnancy, fasting, and rural-urban migration. At York, Müldner and Richards (2007) observed statistically significant differences between the sexes. This was not observed by Lakin (2008), however, who found that the absolute difference between the means for males and females was very small. It is important to note that the sample for Lakin's (2008) study included only individuals from Period 15 and a small number of individuals from Period 16 of St. Mary Spital (see details below), while this study includes individuals from Periods 14, 15, and 17.

Malnutrition has been shown to increase the risk of dental caries. Fasting reduces salivary flow rate, which is directly associated with increased risk of cariogenesis resulting from an increased rate of plaque formation (Johansson, Ericson, & Steen, 1984; Lingström & Moynihan, 2003). England and other regions in Europe experienced severe malnutrition resulting from a series of famines during the medieval period (*c.* 11–16th centuries CE) (Farr, 1846; Keys et al., 1950), which may have increased the prevalence of caries in the population, as malnutrition would have occurred across the entire population. For example, primary sources have noted that in 1258, 15,000 poor people died from famine in London. As deadly as famine was, people did survive medieval famines; in fact, some famine survivors have been identified as such in the East Smithfield Black Death cemetery from London (Antoine, Hillson, Keene, Dean, & Milner, 2005). Exposure to famine might have had long-term effects on health (DeWitte & Slavin, 2013). Episodic, severe malnutrition in the medieval period resulting from famine may have intensified biological and cultural causes of caries frequency differentials between males and females that are evident in contemporary populations.

It should be noted that London has always been a city of migrants. Primary sources and stable isotope data have shown that migrants from other parts of Britain and the near Continent lived in London (Kendall, Montgomery, Evans, Stantis, & Mueller, 2013). However, because of the general climatic deterioration suffered across Europe during the medieval period, episodes of famine were common throughout medieval Europe (Jordan, 1997), and therefore, the presence of migrants should not bias the results of our analysis of London material.

Previous work on the populations from St. Mary Spital and St. Mary Graces has examined sex differences in dental disease (Bekvalac & Kausmally, 2011; Connell, Gray Jones, Redfern, & Walker, 2012). However, neither publication examined the potential effect of age on patterns of caries as is done in this study. Our research examines the interaction of age, sex, and caries in medieval London, during a period of repeated famines, which might have exacerbated underlying biological causes of caries sex differentials.

## 2. Materials and methods

### 2.1. Skeletal samples

The two skeletal samples ($n = 371$) used in this study are drawn from medieval London cemeteries curated by the Centre for Human Bioarchaeology (CHB) at the Museum of London: St. Mary Spital dated to *c.* 1120–1539CE ($n = 291$) and St. Mary Graces dated to *c.* 1350–1538CE ($n = 80$).

#### 2.1.1. St. Mary Spital (c. 1120–1539)

St. Mary Spital (site code: SRP98) was one of England's largest medieval hospitals. It was founded in the twelfth century and was in use until its dissolution in the 16th century (Thomas, Sloane, & Phillpotts, 1997). The stipulations of its foundation charter make it unique in London, because it was charged with hosting and caring for pilgrims and the infirm, and providing care to pregnant women and the offspring of those who died in childbirth (Calendar of Close Rolls 1339-41, 600 cited in Sheppard, 1957). The associated cemetery, which was in use from the 12–16th centuries, contains individuals of all age ranges, from neonates to elderly adults, who were from the city, suburbs, and the infirmary (Connell et al., 2012).

Excavations of St. Mary Spital revealed 10,516 individuals, over half of the estimated 18,000 or so individuals that archaeologists estimated were originally buried in the cemetery (Connell et al., 2012). Of the individuals excavated from St. Mary Spital, 6,950 were 35 percent complete and had regions of the skeleton suitable for estimating age or sex, of which 5,387 individuals of all ages were recorded by the Museum of London Archaeology into the