Famine and Frailty:
Crisis Mortality and Stature in Medieval London

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Introduction

During the 12th - 16th centuries A. D., London was one of Europe's largest urban centers and suffered from frequent cereal shortages that were capable of instigating massive famine-related mortality. To examine biological susceptibility to famine mortality and to test the hypothesis that early-life developmental stress increases risks of mortality from famine during adulthood, this study examines skeletal material from the St. Mary Spital cemetery (SRP98, c. 1120-1540) from London (**Figure 1**).

Materials and Methods

Skeletal Samples

The St. Mary Spital cemetery (SRP98) includes both single interments (type A) and multiple interments arranged horizontally (type B), vertically (type C), or horizontally and vertically (type D) (**Figure 2**). Unlike the type B and C burials, the manner in which the pits for type D burials were dug suggests that they were constructed to accommodate large numbers of deaths within a short time period (1). In addition, the dating and demographic profiles of these interments suggest they were used during famines (1). We selected 152 adults from single interments (Type A) and 56 adults from multiple interments (Type D) to examine the relationship between stature and risk of death under conditions of both normal (non-famine) and famine mortality.

Age and Sex Estimation

Sex was determined based on sexually dimorphic features of the skull and pelvis (2). Adult ages were estimated using transition analysis applied to the public symphysis, iliac auricular surface, and cranial suture closure (3).

Stature

The maximum length of the femur (2) was used as a proxy for adult stature to avoid potential complications arising from using incorrect stature estimation formulae. Previous research found that short stature, based on the combined lengths of the tibia and femur, was associated with elevated risks of mortality during the Black Death in London (4). This study uses the femur in order to maximize sample size for analysis. Individuals were assigned a score of 2 ("short stature") if their femur measurements were more than one standard deviation below the mean for their sex; individuals whose measurements were less than one standard deviation below the mean or were higher than the mean for their sex were assigned a score of 1 ("average or tall stature").

Statistical Analyses

Hazard Model

To assess the relationship between stature and risk of death, stature was modeled as a covariate affecting the Gompertz model of adult mortality within the normal mortality and famine mortality samples using a proportional hazard specification (5).

Positive estimates of the parameter representing the stature covariate would indicate individuals of short stature faced elevated risks of mortality compared to their taller peers.

Parameters were estimated using maximum likelihood analysis with the program *mle* (6).

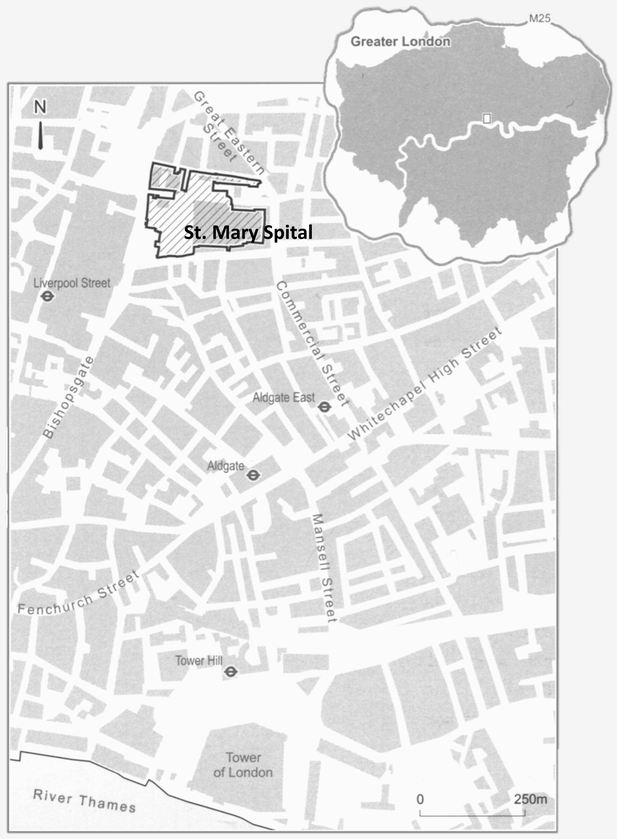

Figure 1: Map of eastern London showing the location of St. Mary Spital cemetery (1).

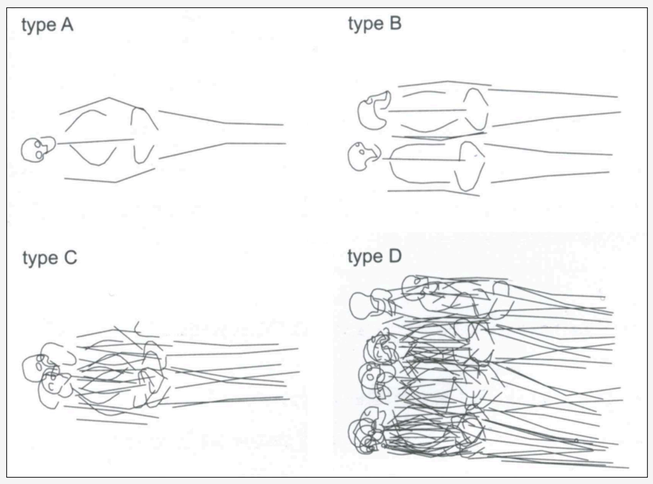

Figure 2: Burial types founds in St. Mary Spital. Modified from Connell et al (1).

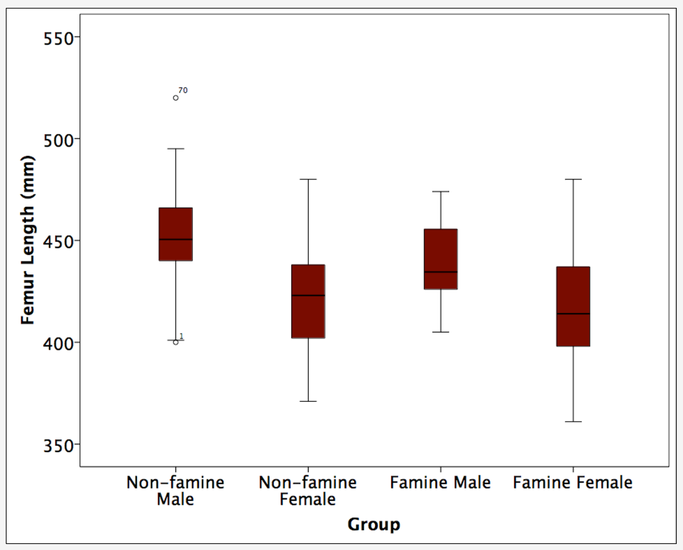

Figure 3: Boxplots of femur lengths by sex and burial type.

Results

Boxplots of femur length by sex and burial type are shown in Figure 3. As expected male femur length is, on average, greater than that of females in both burial types (t-test $p< 0.001$ in each case). Within sexes, non-famine individuals have longer femur lengths than famine victims (males: t-test $p=0.006$; females t-test $p=0.08$).

Table 1 provides the estimated value of the parameter representing the effect of the stature covariate on the adult risk of mortality under conditions of normal and famine mortality. The positive values of the parameter estimates indicate that people who were relatively short were more likely to die than their taller peers in both the normal mortality and famine samples.

	Effect of Stature (95% CI)
Normal mortality	0.77 (0.52, 1.0)
Famine mortality	0.68 (0.28, 1.01)

Table 1: Estimated value of the parameter representing the effect of the stature covariate on the adult risk of mortality

Discussion

These results are consistent with previous findings from London that short stature was associated with increased risks of mortality during the Black Death, and suggest that short stature is a risk factor or a marker for some other, underlying risk factor under various mortality conditions. These results suggest that famine targets individuals who are more frail (or less healthy) than their peers and thus expands our understanding of potential risk factors (i.e. age, sex, socioeconomic status) for famine mortality that have previously that been identified from historical data and in living populations (7). Individuals displaying indicators of previous stressors were not necessarily more susceptible to death directly from starvation during famines, but rather were likely more susceptible to infectious diseases and other causes of mortality that are associated with famine.

These results further demonstrate the worth of hazard modeling within bioarchaeological research, and can lend paleodemographic support to scholars' understanding of famine mortality patterns more generally.

References

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