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Urban and rural mortality and survival in Medieval England

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ABSTRACT

Background: Late medieval England underwent intensive urbanisation, particularly in its largest city: London. Urban dwellers were exposed to factors such as high population density, elevated risk of infection, unsanitary living conditions and precarious food supplies.

Aim: To assess whether the urban environment was more detrimental to health than the rural environment, this study compares risks of mortality and survival, as proxies for health, in medieval urban vs rural England.

Subjects and methods: This study uses samples from rural St. Peter’s cemetery in Barton-upon-Humber, Lincolnshire (c. 1150–1500) and urban St. Mary Spital cemetery in London (c. 1120–1539). Cox proportional hazards analysis and Kaplan-Meier survival analysis are used to assess differences in mortality and survival between urban and rural environments, including differences between sexes.

Results: The results indicate that urban adults faced elevated risks of dying and reductions in survivorship. Specifically, urban females faced elevated risks of dying and reductions in survivorship, while the risks for males were similar in both environments.

Discussion: These results suggest that the effects of urbanisation in medieval England varied by sex. Deleterious conditions associated with urbanisation in London were hazardous for adults, particularly females who may have migrated into London from rural areas for labour opportunities.

Introduction

Transitional periods, associated with such phenomena as agricultural intensification and urbanisation, are of particular interest to bioarchaeologists, as several have concluded that increasing social and economic complexity are associated with dramatic declines in health (Armelagos & Cohen, 1984; Roberts & Cox, 2007; Steckel & Rose, 2002). The United Nations (UN, 1996, 2001a, b) and World Health Organisation (WHO, 1998) have made improving living conditions in cities experiencing rapid urbanisation a priority, and both call for research exploring the health risks associated with the environmental hazards of urbanism. Most of the urban health risks experienced by populations in the past also affect modern populations, including increased levels of infection from overcrowding and inadequate sanitation services and food supplies (Moore et al., 2003). Bioarchaeological research on urbanisation provides a unique temporal depth to our understanding of the hazards of urbanism that clarifies human adaptation to these changes and can contribute to the development of effective planning and prevention strategies for urban expansion.

Environmental archaeology has also contributed to our understanding of urbanisation in late medieval England, specifically the effects of pollution and urban growth on the landscape (see Hall & Kenward, 1994; Schofield, 2011). Bioarchaeological research, however, contributes to our understanding of how the environment may have affected people. By examining the skeletal remains of individuals who experienced urbanisation, bioarchaeologists can elucidate patterns of health and mortality associated with urbanism. Analysis of skeletal assemblages of people exposed to urban environmental factors, such as high population densities, potentially elevated risk of infection and unsanitary living conditions (as described in the Discussion below), can provide unique insights into the effects of urbanisation on health and mortality in the past; particularly when compared to assemblages of people unexposed or less severely exposed to these factors.

Previous bioarchaeological studies investigating health in the context of urbanisation primarily assessed raw frequencies of pathological lesions in urban and rural skeletal samples, interpreting higher levels of pathologies in urban samples as evidence for the negative health effects of urbanisation (Cohen, 1989; De La Rúa et al., 1995; Lewis et al., 1995; Storey, 1992). However, skeletal lesions should not necessarily be interpreted as direct indicators of health because of heterogeneity in frailty and selective mortality.
(Wood et al., 1992). Although previous studies of urbanisation are potentially informative about broad health changes, they reveal little about underlying heterogeneity within urban or rural populations. In order to more adequately address the potentially complex relationship between urbanisation and health, we need to use paleodemographic analyses that allow for intra-population variation in patterns of morbidity and mortality and are, thus, capable of revealing whether urbanisation disproportionally affects certain sub-populations (e.g. males vs females or particular age groups).

Most paleodemographic studies of urbanisation have assessed mortality using traditional approaches, such as comparisons of mean age-at-death or life tables (Nagaoka & Hirata, 2007; Steckel, 2005; Storey, 1985). However, the reconstruction of the health consequences of urbanisation in the past is inherently complex and might be limited by small sample sizes and traditional methods, given the phenomena of demographic non-stationarity, hidden heterogeneity and selective mortality (Konigsberg & Frankenberg, 2002; Vaupel & Yashin, 1985; Wood et al., 1992). The quantitative models applied in this study, however, allow us to account for selective mortality and heterogeneity in frailty. Moreover, the statistical approach used in this study, hazards analysis, accommodates missing data without imposing a particular age pattern on skeletal data (Gage, 1988). Further, this study uses transition analysis, an age estimation technique for skeletal remains that avoids some of the limitations associated with traditional age estimation methods (Boldsen et al., 2002). This age estimation method and the hazards analysis are increasingly being used in paleodemography (e.g. Bullock et al., 2013; DeWitte & Wood, 2008; Wilson, 2014). These approaches, however, have not yet been applied to an investigation of urban–rural mortality and survival differences. This study uses hazards and survival analysis to assess demographic differences between the medieval urban St. Mary Spital cemetery (SRP98) in London (c. 1120–1539) and the contemporaneous rural St. Peter’s cemetery (BOH) in Barton-upon-Humber, Lincolnshire, England (c. 1150–1500).

Methods

Skeletal assemblages

St. Mary Spital (1120–1539)

St. Mary Spital was in use during the early urbanisation of medieval London. Medieval London was exceptional in Britain because of the degree to which the area urbanised and how quickly it did so (Thomas, 2002). Urban centres like London attracted poor people, who were presumably more vulnerable to infections and exhibited high death rates compared to their rural counterparts (Singman, 1999). St. Mary Spital was established for treating the general population of London, and occasionally catered to the religious community (i.e. monks and lay sisters) and some wealthy benefactors. Connell et al. (2012) suggest that, because there are mass burials within the cemetery and because the burial population is larger than the number of individuals that could have been treated at the hospital, the burial population was not limited to hospital inmates and would have also included individuals from the general community of London.

SRP98 is one of the largest urban skeletal assemblages excavated in Europe to date, with 5387 skeletons available for analysis, and is curated by the Museum of London (Connell et al., 2012). Using high-precision Bayesian radiocarbon dating within a well-defined stratigraphic framework, the cemetery has been classified into four distinct chronological phases: 1120–1200 (P14), 1200–1250 (P15), 1250–1400 (P16), and 1400–1539 (P17) (see Sidell et al., 2007 for details regarding phasing of the cemetery using Bayesian modelling). We selected a stratified random sample of 335 skeletons from among skeletons that were at least 50% complete and had the relevant skeletal elements needed for age estimation and sex determination across each of the four temporal phases; the sample sizes are presented in Table 1.

Barton-upon-Humber (1150–1500)

St. Peter’s cemetery at Barton-upon-Humber (BOH), Lincolnshire, England was in use from 1086–1855; excavation of the cemetery yielded 2750 skeletons (Waldron, 2007). BOH includes individuals from all levels of society living in the village and its hinterland (Waldron, 2007). Barton was considered a poor rural community during the medieval period (Clapson, 2005). Although Barton is often referred to as a small town in the literature, it actually never had a charter in the medieval period or any form of corporate government, attributes that typically differentiate a town from a village (Bryant, 2003). The agricultural village did not experience significant urbanisation until the late 17th century when factories sprang up along the River Hull (Clapson, 2005), after the period of interest for this study; thus BOH is appropriately considered ‘rural’ for this study.

The cemetery has been divided into five temporal phases (E: 950–1150, D: 1150–1300, C: 1300–1500, B: 500–1700, A: 1700–1855) using radiocarbon dating of coffins and skeletal remains, dendrochronology of coffin boards, and by establishing relative chronologies through localised grave sequences (see Bayliss & Atkins, 2011 for details regarding cemetery phasing). This phasing permitted the selection of a sample that includes only burials that pre-date urbanisation at Barton. For this study, we sampled 149 individuals equally from two phases in the assemblage (D: 1150–1300 and C: 1300–1500); the sample sizes are presented in Table 1. This includes all skeletons from those two phases that were at least 50% complete. Barton-upon-Humber provides an appropriate rural comparative skeletal assemblage because it is large, well preserved, and provides the approximate temporal phases necessary for comparison with St. Mary Spital.

Table 1. Sample sizes for St. Mary Spital (SRP98) and Barton-upon-Humber (BOH) cemeteries

<table>
<thead>
<tr>
<th></th>
<th>SRP98</th>
<th>BOH</th>
<th>SRP98 + BOH</th>
</tr>
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<tbody>
<tr>
<td>Adults</td>
<td>335</td>
<td>149</td>
<td>485</td>
</tr>
<tr>
<td>Males</td>
<td>166</td>
<td>74</td>
<td>240</td>
</tr>
<tr>
<td>Females</td>
<td>169</td>
<td>75</td>
<td>244</td>
</tr>
</tbody>
</table>

(Boh et al., 1998; Konigsberg & Frankenberg, 2002; Vaupel & Yashin, 1985; Wood et al., 1992).
**Skeletal analysis**

**Sex estimation**

Sex for each individual was determined by examining sexually dimorphic features of the pelvis and skull (Buikstra & Ubelaker, 1994). Skeletal features that were scored include: supraorbital margin, supraorbital ridge, mastoid process, external occipital protuberance, mental eminence, pubic ventral arc, subpubic concavity, ischiopubic ramus and greater sciatic notch. When available, features of the pelvis were weighed more heavily than those of the skull, as the former yield more accurate sex estimates (Meindl et al., 1985; Walsh et al., 2004). Individuals for whom sex determination was not possible or questionable were not included in analyses evaluating sex differentials.

**Age-at-death**

Adult age-at-death was determined using transition analysis (Boldsen et al., 2002) via the ADBOU (Anthropological Database, Odense University) age estimation software. Individuals for whom age could not be estimated (i.e. those adults missing or with poorly preserved age-indicators) were not included in analyses. Only adults were included in this study (i.e. individuals with an estimated age-at-death of 15 years and older).

There are several limitations to and biases associated with estimating age-at-death using skeletal remains, particularly for adults. Unlike sub-adult age estimates, adult skeletal age estimates are typically determined by assessing macroscopic degenerative changes to the skeleton that are also influenced by factors such as environment, genetics, and physical activity throughout life (Bello et al., 2006). In addition to the inaccuracy of degenerative change rates, conventional methods of age estimation risk imposing the age distribution of a known-age reference collection onto the target collection (i.e. age mimicry) (Bocquet-Appel & Masset, 1982). Moreover, traditional age estimation methods assign individuals to broad, pre-determined age intervals. An individual with an age-at-death on the low or high end of a pre-determined age interval could potentially be categorised into an incorrect age interval, resulting in inaccurate age-at-death distributions. Traditional methods also tend to yield only broad terminal age intervals for the oldest individuals in a sample (e.g. 50 and older), limiting assessment of demographic trends at the oldest adult ages. However, transition analysis, the age estimation method used for this project, attempts to avoid these biases by using some of the criteria articulated in the Rostock Manifesto (see Hoppa & Vaupel 2002).

Transition analysis uses data from a known-age reference sample to obtain a conditional probability $Pr(c_{j}|a)$ of a skeleton exhibiting a certain age indicator stage or a suite of age indicator stages ($c_{j}$), given the individual’s known age ($a$). This conditional probability is then combined with a prior distribution of ages at death using Bayes’ Theorem to estimate the posterior probability that a skeleton of unknown age died at a certain age, given that the skeleton displays a particular suite of age-indicator stages. The ADBOU programme uses an informative prior distribution of age-at-death (the Gompertz-Makeham model, see Wood et al., 2002) estimated from 17th-century Danish rural parish records, and the conditional probability of the age indicators given known age at death estimated from the Smithsonian Institution’s Terry Collection. The parameter estimates for the prior distribution estimated from the 17th-century Danish records are: $a_1 = 0.01273$, $a_2 = 0.00002478$, and $\beta = 0.1060$ (J Boldsen, personal communication, 3 September 2008). The skeletal age indicators used in this method include several features of the pubic symphysis and iliac auricular surface, and cranial sutures (Boldsen et al., 2002).

**Statistical analysis**

**Cox proportional hazards model**

The effect of rural vs urban environments on risk of death is evaluated using the Cox proportional hazards model (Cox, 1972) with pooled point estimates of age for adults from both cemeteries and modelling ‘urban’ as a covariate ($0 = \text{rural}, 1 = \text{urban}$). The Cox model is a semi-parametric regression model that estimates relative risk of death, and does not require the specification of the baseline hazard function. The model tests the null hypothesis that the covariate has no effect on the hazard, with the reported hazard ratio indicating the change in risk of death associated with a unit increase in the covariate. Significant ratios ($p < 0.05$) that are greater than 1.0 indicate that the urban covariate is associated with elevated risk of death. Sex differentials in mortality for the urban and rural environments are also evaluated using this approach. To assess whether mortality differences between urban and rural environments are consistent between the sexes, we model ‘urban’ as a covariate affecting the Cox model separately for males and females.

**Kaplan-Meier survival analysis**

The effect of rural vs urban on survival is evaluated using Kaplan-Meier survival analysis, with a log rank test using pooled point estimates of age from both cemeteries and modelling ‘urban’ as a covariate. To assess sex differences in adult survivorship in urban and rural environments, males and females are also analysed separately. All analyses were performed using SPSS Version 21. It is important to note that our analyses do not take into account the errors associated with estimated ages-at-death; thus, the standard errors produced by the Cox proportional hazard analyses and the Kaplan-Meier survival analyses may be under-estimated. Therefore, the results from our analyses should be viewed as informative in so far as they indicate general trends, although the numerical estimates themselves should be viewed with caution.

**Fertility proxy**

Changes in fertility (one possible manifestation of demographic non-stationarity) have been found to alter age-at-death distributions, irrespective of trends in age-specific mortality (Milner et al., 1989; Paine, 1989; Sattenspiel & Harpending, 1983). In a population experiencing an increase
in fertility, for example, increasing numbers of children will be born each year, thus increasing the number of children who die each year, even if age-specific mortality rates do not change. Ultimately, under these circumstances, the resulting cemetery assemblage from this growing population will contain an excess of young individuals relative to older individuals. This phenomenon makes it difficult to infer mortality patterns directly from age-at-death data from cemetery samples (Milner et al., 2008) and complicates the comparison of two different, contemporaneous assemblages that are potentially derived from populations with different fertility rates.

In this study, we control for fertility by examining the number of individuals 30 years of age and above divided by the number of individuals 5 years of age and above (i.e. $D_{30+}/D_{5+}$). There is a strong negative relationship between $D_{30+}/D_{5+}$ and birth rate (Buikstra et al., 1986), and the corresponding 95% comparison intervals can be informative about whether birth rates differ significantly across samples.

Although our use of this fertility proxy allows us to infer whether differences in estimated survivability and mortality between the rural and urban assemblages are artefacts of differences in fertility between the populations, it does not resolve the potential influence of migration. As is often the case with bioarchaeological research, we make the assumption that the populations under consideration were stable (closed to migration and with constant age-specific fertility and mortality rates). This assumption is reasonable, as most populations appear to have stable age structures (Gage et al., 2012). Although previous modelling work has shown that demographic perturbations (resulting, for example, from crisis mortality associated with famine or plague) can have effects on age-at-death distributions that last for several decades (Paine, 2000; Weiss, 1975), substantial effects are relatively short-lived. Given the relatively long period of time across which our samples from both cemeteries are drawn, such potential effects of temporary perturbations in demographic patterns are likely not strong enough to affect our conclusions.

It is possible, however, that migration during this period might affect our results. We describe the possible influence of migration on our findings in the Discussion.

## Results

### Age-at-death distributions

The age-at-death distributions from SPR98 and BOH cemeteries for all adult ages are shown in **Figure 1**. The results of a Kolmogorov-Smirnov test indicate that the two distributions are significantly different ($p < 0.001$). As shown in **Figure 1**, there are more young adults (15–20 years of age) in SPR98 compared to BOH. After 20 years of age, the adult distributions are similar until 40 years of age; however, BOH has a higher proportion of individuals 40–70 years of age, and SPR98 has a slightly higher proportion of individuals above the age of 70.

### Cox proportional hazards model

The results of the Cox proportional hazard analyses are shown in **Table 1**. The estimated hazard ratio, when sex is pooled, is significant and greater than 1.0, with the corresponding confidence interval including only values above 1.0. These results suggest elevated risks of mortality for adults in the urban environment compared to those in the rural environment.

The sex-specific results are also shown in **Table 2**. For females, the hazard ratio is significant and greater than 1.0, with the corresponding 95% confidence interval including

<table>
<thead>
<tr>
<th>Exp(B)</th>
<th>95% CI</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>1.225</td>
<td>1.009–1.487</td>
</tr>
<tr>
<td>Males</td>
<td>1.104</td>
<td>0.837–1.457</td>
</tr>
<tr>
<td>Females</td>
<td>1.349</td>
<td>1.023–1.779</td>
</tr>
</tbody>
</table>

**Figure 1.** Age-at-death distributions from St. Mary Spital (SRP98) and Barton-upon-Humber (BOH) cemeteries.
only values above 1.0. For males, however, although the hazard ratio is greater than 1.0, it is not significant, and the corresponding 95% confidence interval includes 1.0 and values below 1.0. Together, these results suggest that females faced elevated risks of dying in the urban environment, while the risks of dying for males may have been similar in both environments.

**Kaplan-Meier survival analysis**

The results of the Kaplan-Meier survival analysis are shown in Table 3, and the survival curves are shown in Figure 2. The survival functions reveal a significant difference in mean survival time between BOH and SRP98 (Mantel-Cox $p = 0.038$), and the corresponding 95% confidence intervals for the two cemeteries do not overlap. This suggests that urban adults had lower survivorship compared to rural adults.

The sex-specific Kaplan-Meier results are shown in Table 3, and the survival curves are shown in Figures 3 and 4. For females, there is a significant difference in mean survival time between BOH and SRP98 (Mantel-Cox $p = 0.044$), with slightly overlapping 95% confidence intervals (~1 year of overlap). There is no significant difference in mean survival time between urban and rural males, and the male 95% confidence intervals overlap substantially. These results suggest that urban females had reduced survivorship compared to rural females, but males experienced similar survivorship in rural and urban environments.

**Fertility proxy**

The fertility proxies and their corresponding 95% confidence intervals for both cemeteries are provided in Table 4. The $D_{30}/D_{50}$ value for BOH is higher than the $D_{30}/D_{50}$ value for SRP98, which suggests that birth rates may have been lower in the rural environment compared to the urban environment. However, the comparison intervals for the two cemeteries substantially overlap, indicating a lack of significant difference in birth rates between the two.

**Discussion**

The results of these analyses suggest that, for adults in general, there were elevated risks of mortality and reductions in survivorship for individuals in the urban environment compared to the rural environment. However, separate analyses of males and females reveal that females faced elevated risks of dying and reductions in survivorship in the urban environment, but the risks for males were similar in both environments. These demographic differences between the two cemeteries do not appear to be an artefact of differences in birth rates. The inconsistent trends in mortality and survivorship suggest that the effects of urbanisation in medieval England varied by sex.

The observed elevated mortality and, by inference, compromised health in the urban environment for adults in this study are consistent with previous bioarchaeological investigations of urbanisation (Lewis et al., 1995; Morfin et al., 2002; Storey, 1985). For example, comparison of age-at-death distributions between rural Wharram Percy and urban...
St. Helen-on-the-Walls in medieval York also indicates that urban dwellers did not live as long as rural villagers (Roberts et al., 1998). It is traditionally argued that urban living is inherently risky because of high population density, sanitation issues, water and air pollution, high prevalence of infectious disease and famine (Moore et al., 2003). Differences in adult mortality and survivorship between the two cemeteries in this study might reflect detrimental environmental conditions in London compared to Barton-upon-Humber. London was the largest urban centre in England during the Late Medieval Period, and experienced rapid population increase, doubling or even quadrupling from the 13th to the 14th century (Schofield, 2011; Williams, 1963) (estimates of the population size at the beginning of the 14th century range from 40,000–80,000 (Holt & Rosser, 1990)). With density increasing rapidly in such a short period of time, waste disposal and subsequent pollution and water contamination were inevitable problems in London.

Concerns about sanitation in medieval London are evident in the implementation of legal regulations for waste disposal and basic sanitation systems (Sabine, 1934, 1937). City ordinances indicate that London residents were responsible for

### Table 4.

<table>
<thead>
<tr>
<th></th>
<th>$D_{30}^{+}/D_{5}^{+}$</th>
<th>95% CI</th>
</tr>
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<tbody>
<tr>
<td>SRP98</td>
<td>0.364</td>
<td>0.284–0.444</td>
</tr>
<tr>
<td>BOH</td>
<td>0.450</td>
<td>0.337–0.563</td>
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Figure 3. Kaplan-Meier survivorship curves with 95% confidence intervals for females of St. Mary Spital and Barton-upon-Humber cemeteries.

Figure 4. Kaplan-Meier survivorship curves with 95% confidence intervals for males of St. Mary Spital and Barton-upon-Humber cemeteries.
dealing with their own waste and that householders and businesses were responsible for keeping the areas outside of their property clean, properly paved and clear from obstruction (Jørgensen, 2008). In the late 13th century, officials were also appointed to oversee streets and pavements (Sabine, 1937). Several directives for public sanitation were repeated from the 12th to 14th centuries (Sharpe, 1905), which suggests that efforts to keep the city clean were not successful.

Unlike London, English villages similar to Barton generally had plenty of space to dispose of their refuse away from residences (Hallam, 1981). Food, household and stable wastest were often taken to a common area at the periphery of the village that neighbours shared (Miller & Hatcher, 2014), given to pigs owned by the household (Albarella, 2006) or used for agricultural production in fields (Duby & Postan, 1998; Jones, 2011). At the English village of Wharham Percy, a lack of rubbish pits near households and absence of animal bone near the residential area indicate that household waste was carted to field areas where large quantities of pottery have been recovered (Beresford & Hurst, 1991).

Sanitary issues and animal waste in the streets of urban areas inevitably led to water contamination. Within medieval London’s geology, there was a plentiful supply of well and spring water (Keene, 2001). However, most springs were inconveniently located at the edges of the city, and most wells were within private properties, only accessible to the owners (Schofield, 2011). Londoners without wells most likely used suburban streams for their domestic water needs, which were polluted as a result of waste drainage (Keene, 2001) and close proximity to latrines (Schofield, 2011).

Water-borne infections are sustained through pollution of drinking water, which was not prevented in England until the 19th century (Waldron, 1989). Waterleaders sold water from the Thames to residents (Ekwall, 1947), even though it also served as the ultimate method of waste disposal for London (e.g. latrines were built over running waterways that eventually emptied into the Thames (Keene, 2001)). Boyd’s (1981) archaeological study of sediments at the Thames and Fleet rivers indicate increasing pollution during the same time that Edward III ordered the mayor of London to clean the area in the early 14th century. In 1237, construction began on the first conduit system, which provided taps at intervals throughout the city (Sharpe, 1899). However, because the Conduit could not meet the demand of the Londoners and fee for its use was eventually forced, the poor most likely used the more easily accessible, albeit polluted, Thames as their main source of drinking water (Gummer, 2009).

In contrast to London, acquiring fresh water was not an issue at Barton-upon-Humber, because several streams traversed the area, flowing into the marshes of the River Humber, and were readily accessible to residents (Rodwell & Atkins, 2011). Residents also used The Beck, which was fed by an artesian spring, to acquire their drinking water (Lyman, 2004; Rodwell & Atkins, 2011). Water supplies at Barton were likely not at a risk for contamination, because rural areas had more space for latrines and waste disposal.

High population density paired with unhygienic conditions made urban dwellers susceptible to infection. Thus, the prevalence of infectious disease may have been higher in London compared to rural areas. Common diseases noted in late medieval London include leprosy, tuberculosis and syphilis (Roberts & Cox, 2003). BOH exhibits remarkably few (skatally diagnosable) cases of infectious diseases, such as tuberculosis, compared to contemporaneous urban areas in medieval England (Waldron, 2007). Waldron (2007) suggests that Barton may have been immune from the general upsurge in the disease; although it is possible that diseases affecting the population may have been particularly virulent, causing deaths before the skeleton was affected.

It is possible that the elevated risks of dying and reductions in survivorship in the urban environment reflect the effects of the 14th century Black Death and subsequent outbreaks of plague. Although all of England experienced outbreaks of plague, it might have been more problematic in urban areas, as urban dwellers often fled to rural areas to avoid it (Schofield & Vince, 2003). However, there are conflicting views on whether towns or rural villages experienced plague differently. Some scholars argue that higher population density caused elevated mortality rates in towns (Britnell, 1994; Wrigley, 1969), while others argue that rural areas experienced higher plague mortality (Benedictow, 2004, 2005). Evidence of plague and other short-term fluctuations in mortality are not evident in the BOH skeletal assemblage (e.g. there is no evidence of multiple deaths during a short period of time), but are apparent in parish records (Waldron, 2007). In 1593, an outbreak of plague in Barton resulted in 203 deaths (~26% of the population) and was recorded in parish records (Waldron, 2007). This level of mortality is consistent with estimates of plague mortality in 17th century London (Cummins et al., 2015), which suggests that plague mortality might not explain the urban vs rural differences observed in this study.

Healthcare may have been more accessible at Barton than in London, as several doctors and apothecaries are included in the parish registers (Watts, 2013). However, these parish registers did not begin until the 16th century. Care received at SRP98 would have involved spiritual care from the Augustinian canons and nursing care from the lay sisters, with little medical intervention, at least until the 15th century (Thomas, 2000). There is some evidence of physicians at the hospital in the late 15th and early 16th century, but it is not conclusive (Thomas, 2000).

During this time, England experienced several famines resulting from changing climate conditions. These adversely affected food production in neighbouring rural areas from which London acquired most of its food (Farr, 1846; Keys et al., 1950). Rural areas like Barton that were dependent on agriculture, however, may have been better buffered from the famines that occurred during this time. In London, only a few urban residences had land for small gardens (Connell et al., 2012), while village residences could turn to their own fields and livestock rather than selling them for sustenance during times of poor harvest. Thus, the effect of famine could have exacerbated the potentially detrimental effects of urbanisation, making nutritional differences and, thus, potentially health differences between urban and rural populations more pronounced.
Rural-to-urban migration is one of the most common types of human movement in all periods of recorded history (Boyce, 1984), allowing cities with high mortality rates to sustain high population densities (McNeill, 1980; Wrigley, 1969). Migrants made up a large proportion of the population in London (Wrigley, 1969). Immigrants to urban environments might have faced elevated risk of infection with diseases they did not encounter during their childhoods in rural areas. Some studies find that migrants from rural to urban environments in modern populations have elevated risk of disease compared to urban residents (Baker, 1984; Velimirovic, 1979; Way, 1976). Moreover, rural-to-urban migrants can be exposed to disease during the migration process (Prothero, 1977). Thus, hazardous conditions experienced by rural immigrants to London may have contributed to the elevated risk of urban adult mortality for SRP98 observed in this study.

Migration into London from neighboring rural areas was particularly common among adolescents and young adults, especially females, because of greater economic opportunities (Dyer, 2002; Hanawalt, 1995). Evidence for this pattern of rural-to-urban migration is evident in the higher proportion of young adults in the age-at-death distribution of SRP98 compared to BOH (Figure 1). According to tax documents, urban cities had more female servants than male servants (Kowaleski, 2014). After the Black Death (1348–1349), the number of young females in urban areas increased (Lewis, 2016). Female servants were charged with sex-specific food preparation tasks, which could have increased their exposure to zoonotic diseases (Smith, 1997). Osteological evidence of the strain of domestic labour on urban females compared to rural females is evident in medieval English skeletal assemblages as well (Lewis, 2016). A significant proportion of females in medieval London also suffered from poverty (Leyser, 1995), often living in over-populated and unsanitary conditions, which would have increased their risk of infection (Taylor, 1983). Moreover, the progression from infection to disease and risk of fatality for reproductive aged females is higher compared to males, at least for some diseases such as tuberculosis (WHO, 2003), which was increasing in England prior to the Industrial Revolution (Chalke 1962). Through an analysis of 151 sites in Medieval England, Lewis (2016) found that young urban females showed elevated frequencies of diseases compared to urban and rural male and rural female adolescents (aged 6.5–25 years), which she attributes to young urban females being more vulnerable to disease than other groups. All of these factors could have contributed to increased risk of mortality for young females migrating from surrounding rural areas to London, which is consistent with the elevated mortality and reduced survivorship of urban vs rural females in this study. Similarly, at St. Helen-on-the-Walls, an English urban cemetery, there was a larger proportion of females aged 25–34 compared to males (Dawes, 1980). Similar patterns were also found in St. Mark’s, Lincoln and York Minster, York and were attributed to female-led migration (Grauer, 1991). It is important to emphasise the possibility that the elevated mortality and reduced survivorship of females from SRP98 might actually be a reflection of a higher proportion of young females migrating into London from surrounding areas rather than elevated mortality of females after they migrated to London. With respect to the rural cemetery, this sex-specific migration pattern could have resulted in a lower proportion of young females in BOH because they have migrated into urban areas like London and, thus, would have been buried in urban cemeteries. Not all females were permanent immigrants, however, as it was not uncommon for females to return to their rural villages to marry after working in an urban area as an adolescent (Bitel, 2002; Goldberg, 2004).

Conclusion

The results of this study suggest that the effects of urbanisation in medieval England varied by sex. Comparison of the urban St. Mary Spital cemetery in London and rural St. Peter’s cemetery in Barton-upon-Humber via hazards and survival analysis of pooled-sex samples indicate that urban adults, in general, experienced elevated mortality and reduced survivorship. These results are consistent with most previous bioarchaeological studies comparing urban and rural environments. Environmental factors that are characteristic of urban centres such as high population density, elevated risk of disease, poor sanitary conditions and famine may have contributed to the detrimental effect of the urban environment on health, and thus mortality and survival.

Analysis by sex, however, suggests that females in the urban sample experienced elevated risks of mortality and reduced survival compared to rural females, whereas males faced equal risks in both environments. These results may be a consequence of a higher proportion of females migrating from rural to urban centres in search of work opportunities. These females may have suffered from poverty, famine and exposure to pathogens during immigration or upon their arrival in the city, all of which could have increased their risk of mortality.

This study considers mortality and survival trends among males and females in urban and rural cemeteries, allowing us to examine potential heterogeneity within the urban and rural environments. The elevated mortality and lower survival for urban females compared to rural females was apparent once the sexes were analysed separately, and may have contributed to the overall mortality differences of adults between the two cemeteries. Although general comparisons of cemeteries are informative about broad demographic differences or similarities, it is important to use approaches that allow for the examination of heterogeneity in past populations so that intra-population variation in mortality patterns can be identified and potential disproportionate effects of urbanisation on sub-populations may be revealed. Additionally, this study contributes a unique bioarchaeological line of evidence for the investigation of differential mortality in the context of urbanisation beyond primary documents that often exclude the poor and migrants, which comprised the bulk of the population of Late Medieval London.

Finally, urban towns and cities have their roots in rural villages, making the relationship between town and country inherently complex. Migrants contribute to demographic
patterns within urban centres, but are often invisible from primary historical documents. Future studies using stable isotope analysis to identify migrants in urban centres can offer valuable information regarding where migrants were coming from, who these migrants were (e.g. young females) and how these migrants experienced and adapted to the environmental factors characteristic of urbanism. The integration of biochemical research (e.g. stable isotope analyses) with paleodemography is essential for disentangling the complicated links between mortality, fertility and migration to better understand medieval life in the face of a changing climate.

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Disclosure statement

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