Urbanization and respiratory stress in the Northern Low Countries: A comparative study of chronic maxillary sinusitis in two early modern sites from the Netherlands (AD 1626–1866)

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Abstract
The aim of this study was to investigate the relationship between urbanization and upper respiratory health in two early modern populations from the Netherlands. For this purpose, we analyzed the prevalence of chronic maxillary sinusitis in the adult urban population of Arnhem (n = 83) and in the rural village of Middenbeemster (n = 74). A slightly higher prevalence of chronic maxillary sinusitis was observed in the Arnhem sample (55.4%) compared with the Middenbeemster sample (51.3%), and these variations were not statistically significantly different. Although historical sources attest to the fact that life in the postmedieval settlements of Arnhem and Middenbeemster greatly differed, our results suggest that both environments exposed people to certain respiratory hazards. Furthermore, sinusitis prevalence was also investigated in correlation to sex, as urbanization in the Netherlands often involved women in factory work in direct contrast to the traditional domestic role they kept covering in rural environments. No significant differences were observed between males and females, both in an intersite (Arnhem males vs. Middenbeemster males; Arnhem females vs. Middenbeemster females) and in an intrasite (males vs. females at Arnhem; males vs. females at Middenbeemster) comparison. As men and women in Arnhem worked on similar tasks, our results confirm that they were both exposed to similar risk factors. In Middenbeemster, where women mainly stayed inside taking care of the house while men worked the fields, the adverse weather conditions and continuous exposure to pollens and allergens may have enhanced men’s chances of contracting chronic maxillary sinusitis. This study suggests that urbanization in the early modern Netherlands was in fact not inherently more detrimental than rural living. Future research incorporating a larger sample from other Dutch sites is being considered to better frame the complex etiology of sinusitis within the present understanding of historic regional variation in urbanization patterns.

KEYWORDS
endoscope, infection, paleopathology, paranasal sinuses, urban development
**INTRODUCTION**

Chronic maxillary sinusitis (CMS) is the inflammation of the lower paranasal sinuses, small air-filled chambers that surround the nasal cavity (Figure 1) with the function of defending against inhaled particulate matter and pathogens. This occurs through the production of mucus carried by small hairs toward an opening (ostium) situated on the superior part of the sinus, where particulates and pathogens are drained (Slavin et al., 2005; Stannard & O’Callaghan, 2006). When drainage does not occur and the ostium is obstructed, mucous fluid starts to accumulate in the sinus. When built up, mucous fluid provides an ideal environment for bacterial and fungal growth, thereby contributing to the inflammation of the mucosal membrane and, subsequently, the bone surface (Kocak et al., 2002).

Even though most episodes of acute sinusitis are caused by viral upper respiratory tract infections (Rosenfeld, 2016), several other factors play a key role in the development of the condition. Asthma, allergic rhinitis, smoking, and cold and humid climates facilitate bacterial growth in the sinus cavities (Berrettini et al., 1999; Slavin et al., 2005), whereas environmental risks such as household air pollution, second-hand tobacco smoke, and population crowding are regularly reported as significant contributors to sinus infection (e.g., Hur et al., 2014; Min et al., 1996; Simkovich et al., 2019).

Today, the global prevalence of chronic sinusitis measured in epidemiologic studies varies from 5% to 12% (de Loos et al., 2019). In the Netherlands alone, 500,000 people are diagnosed with chronic sinusitis every year (KNO, 2010). Symptoms of sinusitis include nasal obstruction, headaches, fever, coughing, and facial pain (Rosenfeld, 2016). Complications can include eye infection, meningitis, and brain abscess (Carr, 2016; Ziegler et al., 2018). Due to the high incidence of sinusitis, clinical research has recently focused on the development of new strategies to prevent and treat its onset, endeavoring to bring the public’s attention to the correct ventilation of indoor environments and raising awareness of the role air pollution plays in respiratory health (World Health Organization [WHO], 2016). Yet, although the high burden of upper respiratory disease is often considered to be a product of the modern world, several historical and bioarchaeological sources attest to the fact that CMS was also a frequently occurring problem in the past (e.g., Bernofsky, 2010; Lewis et al., 1995; Roberts, 2007; Sundman & Kjellström, 2013a; Wells, 1977).

1.1 | CMS and urban development

Today, urban residence is considered a major risk factor for respiratory diseases such as sinusitis (Brugha & Grigg, 2014; D’Amato et al., 2010). As the world is facing its biggest urbanization wave, scholars have started to focus on the consequences this will have, including significant changes in living standards, lifestyles, social behavior, and health (e.g., Delisle et al., 2012; Gong et al., 2012; Strodnier et al., 2017). Health challenges, particularly evident in urban realities, relate to water supply, poor nutrition, disease outbreaks, and chronic respiratory conditions (Godfrey & Julien, 2005). In fact, modern epidemiological research has highlighted several differences in health between people living in urban and rural environments, respectively, especially when referring to developing countries where the health gap between urban and rural inhabitants is most significant (Boadi et al., 2005; Verheij et al., 1998).

Previous bioarchaeological studies on urbanization generally confirm a significantly higher incidence of infectious disease and non-specific stress markers in urban populations than in rural ones (e.g., Lewis, 1999; Walter & DeWitte, 2017). In the case of CMS, it is believed that increase in air pollution, poor hygienic conditions, and
To study the potential differences between rural and urban respiratory health, Lewis et al. (1995) investigated CMS rates in the medieval British urban population of St Helen-on-the-Walls and in the contemporary rural population of Wharram Percy. Individuals from St Helen-on-the-Walls showed a significantly higher prevalence of maxillary sinusitis when compared with the ones from Wharram Percy (Lewis et al., 1995). More recently, Sundman and Kjellström (2013a, 2013b) investigated frequencies of maxillary sinusitis in several urban, proto-urban, and rural settlements from early-medieval Sweden. Results showed significantly lower frequencies of bone changes in individuals associated with rural environments in comparison with those living in the urban settlement under investigation (Sundman & Kjellström, 2013b). These studies suggest that urban environments have potentially exposed people to several risk factors for respiratory disease, therefore leading to a more compromised sinus health in people living in towns in contrast to those living in the countryside. However, another study on the occurrence of CMS in the urban population of St. Bride's Lower Crypt, London, and the nearby semiurban settlement of Chelsea Old Church found no statistically significant differences (Bernofsky, 2010). This may indicate that variations in lifestyle and environment were sufficient to produce significant differences in the frequency of sinusitis.

Although it is generally acknowledged that the past urban environment tended to have a consistent impact on the respiratory health of citizens, it must also be considered that urbanization occurred throughout the whole European continent with substantial regional variation, meaning it probably affected people's lives in extremely different ways (Blockmans, 2011). This makes it challenging for bioarcheologists to define the gap between rural and urban livings and to truly understand the impact urbanization had on people's health. In the present paper, we contribute to this discussion by adding data on CMS from two early modern contexts from the current Netherlands in order to broaden our perspective on how urbanization affected human well-being.

1.2 | Urbanization and health in the Netherlands

In the area currently known as the Netherlands, the growth of centers in the 13th century allowed the region to rapidly develop from a cluster of scarcely populated, agricultural realities to what is today considered the first European urbanized area (de Vries, 1984; van Zanden, 1993). Hart (2001) estimates that, at the beginning of 17th century, 42% of the total population resided in a town. The population density kept growing rapidly until the 19th century, in some cases without control, resulting in rates comparable the ones of other larger European realities such as Paris or London (Bairoch et al., 1988). Life in these newly formed towns must have been substantially different from the life in the countryside and likely represented a new challenge to many citizens. With the raising population number, infectious diseases started to become increasingly more common among citizens. Fevers and epidemics were considered as endemic in every Dutch town, alongside chronic digestive and respiratory illnesses (van Poppel, 2018; Wintle, 2000). Although most historical sources point out a negative impact of urban living on people’s health (e.g., Houwaart, 2018; van Poppel, 2018; Wintle, 2000), recent bioarcheological studies focusing on infectious disease, activity markers, and dietary deficiencies in several Dutch populations observed the absence of a marked distinction between town and countryside. Schats (2016) investigated the patterns of infectious disease and activity markers in several late-medieval rural and urban settlements from the Dutch provinces of Holland and Zeeland, concluding that inhabitants of all settlements faced significant threats, which physically impacted their lives. Before that, Panhuysen et al. (1997) looked for CMS in three populations from both urban and rural contexts from the Southern Netherlands but found no significant differences in the prevalence of CMS within their samples. However, they observed that lesions associated with CMS occurred less frequently in males than in females when comparing the total sample and argued that such differences in occurrence may indicate a deeply gender-based division of labor, in which women spent more time near open fires and smoke or in close contact with infected children (Panhuysen et al., 1997). This hypothesis is generally confirmed by other bioarcheological studies on sinusitis (e.g., Roberts, 2007; Sundman & Kjellström, 2013b). Roberts (2007) assessed the presence of CMS in 15 populations from all over the world and observed that females generally showed higher rates than their male counterparts. It was suggested that a gender-based division of daily tasks and activities could have contributed to different sinusitis rates, as the traditional domestic role women had in most societies may have exposed them to smoke from indoor fires and stoves (Bruce et al., 2002; Roberts, 2007).

Throughout the Netherlands, male and female roles were thought to be complementary (i.e., different) until at least the 20th century. Men were supposed to work hard for their family and for the society, whether women were socially restricted to their homes and tended tasks such as milking cows, preparing meals, sewing and washing clothing, and taking care of the children (van Nederveen Meerkerk, 2015; van Poppel et al., 2009). However, several historical sources also attest that women from larger settlements were often involved in factory work and were regularly employed to carry on the same tasks as men (van Laar, 1966; Wintle, 2000). It appears then clear that life and health experiences in the Netherlands at the time of urbanization were different and dependent on the context. The current study aimed to explore the relationship between urbanization and respiratory health in two Dutch early modern contexts using CMS as a proxy. The assemblages included in the sample come from the rural area of Middelenenbemster (19th century) and from the urban center of Arnhem (17th–19th century). On the basis of previous research on Dutch urbanization, we tested the hypothesis that both urban and rural environments somehow challenged people’s respiratory health (i.e., individuals from both settlements would show similar rates of CMS). Furthermore, we also hypothesized higher CMS occurrence rates in women compared with men due to traditionally gender-divided occupational activities and social behaviors.
2 | MATERIALS

The skeletal populations under study (Figure 2) are both currently housed at the Laboratory for Human Osteoarchaeology, Faculty of Archaeology, Leiden University. They were chosen for their ideal preservation and skeletal completeness and for their well-understood historical and osteoarchaeological context. Together, they represent a well-documented window on the life of the middle–lower socioeconomic classes prior to the industrial revolution in the Netherlands.

2.1 | Middenbeemster

The first population \((n = 74)\) was retrieved from Middenbeemster, a rural village in the province of North Holland. The skeletal collection was excavated from the cemetery on the south side of the church in 2011. During excavation, more than 450 individuals were recovered representing all sex and ages. Although the cemetery started to host burials in 1638, the skeletons in our sample dated to the last period of use, namely, 1829 to 1866 AD (Griffioen, 2011). As at the time this was the only cemetery active in the area, the population under study is believed to be representative not only of the people of Middenbeemster but from the surrounding countryside as well (Falger et al., 2012).

In the early 17th century, Middenbeemster was one of the first towns established in the reclaimed Beemster polder, a former lake artificially dried to increase local agricultural production (Aten et al., 2012). In 1840, the Beemster community counted 2971 people, many of which resided in their own farm in the countryside and traveled daily between the farmsteads, hamlets, and Middenbeemster, where the school, main market, and other central facilities were located (Falger et al., 2012). Houses and farms were built similarly throughout the whole Beemster area, according to the typical “stolpboerderij” (bell jar) shape, which allowed the storage of hay and, in the winter, often necessitated sharing living environments with cattle (Aten et al., 2012; de Wit, 2003). Because gas systems reached Middenbeemster in ca. 1900 and wood resources were limited, heating was most likely provided by charcoal stoves and smoke was removed by a single chimney in the main room or in the kitchen (Aten et al., 2012; Wintle, 2000).

Until the 20th century, daily activities in the Beemster polder focused on manual labor and mainly concerned cattle farming, dairy production, and agriculture (Falger et al., 2012). Previous osteological research on activity markers among individuals from the Beemster area indicated that people engaged in extremely physically demanding daily labor. Men were more often performing tasks that required heavy lifting, whereas women performed more tasks associated with pushing or pulling at objects (e.g., using a scrubbing board on laundry) (Palmer et al., 2016). In a study on the prevalence of rickets and osteomalacia in the Middenbeemster assemblage, Veselka et al. (2013, 2018) observed how young women and children had higher rates of rickets osteomalacia compared with adult men. It was argued that, while men worked in the fields, women and children would spend most of their time indoors, inhibiting sunlight exposure and therefore

FIGURE 2  Map of the Netherlands showing the location of the sites under study
developing low vitamin D level and, ultimately, rickets and osteomalacia (Veselka et al., 2013, 2018).

2.2 | Arnhem

The second population consisted of 83 individuals from the city of Arnhem who were interred between 1626 and 1829 AD, when the public graveyard was moved elsewhere (Baetsen et al., 2018). The skeletal assemblage was excavated in 2017 in the northern courtyard of the St Eusebius’ Church and comprised approximately 350 skeletons representing all sex and ages. Although it seems that the Beemster polder was characterized by little social differentiation (Palmer et al., 2016), the population of Arnhem was likely divided in several socioeconomic classes. The location of the burials or our sample (i.e., the northern side of the cemetery) is therefore meaningful and suggests that the individuals under study belonged to a lower-middle economic class, likely workers in the small-scale industry (Baetsen et al., 2018; Palmer, 2019).

Thanks to a continuous inflow of newcomers started in 1795, Arnhem quickly doubled its size from 10,000 registered inhabitants to nearly 20,000 in the second half of the 19th century, when immigration slowed down and the city started to invest in its industrial sector (Boostra et al., 2007; van Laar, 1966). Until then, the working class of Arnhem was mainly employed in small-scale manufacturing, with shoemaking and tobacco production being the most common options for workers (van Laar, 1966). Both men and women were involved in manual labor and typically worked from 12 to 20 h/day (Wintle, 2000). Throughout all the Netherlands, factory conditions were generally grim enough to affect health directly: employees were often exposed to dust and chemicals, and occupational accidents were frequent and often caused by unsafe working environments (van Braam, 1978; Wintle, 2000).

With more and more people coming to Arnhem in search of employment, the municipality soon became unable to provide adequate housing facilities to most of the workers. Densely packed houses were rapidly built to house the newcomers, often in the form of dark, humid, residential barracks, with little or no ventilation to allow residents to breathe properly. In most cases, several people ate and slept in the same room with no space for privacy nor hygiene (van der Woud, 2010). Starting from the beginning of the 19th century, Arnhem was at the center of many campaigns launched to improve the living and working conditions of lower socioeconomic class citizens. Many cases of extreme sanitary conditions were recorded by the time the city was inspected, although the municipality did not take concrete actions to improve the life of citizens until much later in time (van Laar, 1966).

3 | METHODS

Originally, the sample (Table 1) was limited to adult individuals (i.e., age at death ≥20 years old) with at least one observable maxillary sinus observable (i.e., more than 25% present). However, the overall completeness of individuals from both skeletal collections allowed us to select only individuals with both sinuses available for observation. Nonadults were not included here, as the porosity associated with dental development in subadults can be falsely conflated with sinusitis (Lewis et al., 1995). As dental disease (i.e., severe caries lesions, abscesses, and granulomas) can influence the presence of and even cause sinusitis (Patel & Ferguson, 2012), individuals with dental decay in the upper premolars and molars were excluded from analysis. Additionally, individuals who exhibited signs of other infectious conditions such as tuberculosis or leprosy, or other nonspecific lung disease diagnosed by lytic lesions in the vertebrae and/or new bone formation on the visceral surface of the ribs, were excluded, as their relationship with sinusitis is not yet clear (Boocock et al., 1995b; Davies-Barrett et al., 2019; Kiris et al., 2007; Slavin et al., 2005; Upadhyay et al., 2014).

For every individual, sex was estimated on the basis of observation of morphological features on the skull (Buikstra & Ubelaker, 1994) and pelvic (Brzek, 2002; Phieince, 1969).

Fragmented sinuses were carefully cleaned using a dry toothbrush and, when needed, water to remove adhering dirt without damaging the delicate surface of the inner walls. If the sinuses were not observable with the naked eye, they were examined with a flexible medical endoscope (ø = 4 mm; view angle = 30°) inserted through minor breaks naturally occurring on the lower orbital wall and/or on the inferior nasal conchae and palatine bone, where the bone tissue is thinner (Figure 3). In cases where the shape of the skull did not allow the endoscope to move freely, two additional optical adaptors (view angles = 70° and 90°, respectively) were applied on the edge of the camera to ensure precise analysis.

A sinus without pathological changes presents smooth surfaces with little associated pitting and channels for blood vessels. Lesions associated with CMS as defined by Boocock et al. (1995a) were recorded for each individual and classified as “pitting,” “spicule-type bone formation,” “remodeled spicules,” or “white pitted bone.”

| TABLE 1 | Demographic composition of the skeletal assemblages |
|----------|---------------------------------|----------|---------------------------------|----------|
|          | Middenbeemster                  | Arnhem   |                                  |          |
|          | 20–34 years | 35–49 years | 50+ years | Total | 20–34 years | 34–49 years | 50+ years | Total |
| Males    |            |            |           |       |            |            |           |       |
|          | 7          | 10         | 17        | 34    | 16         | 13         | 15        | 44    |
| Females  | 14         | 14         | 12        | 40    | 14         | 21         | 4         | 39    |
| Total    | 21         | 24         | 29        | 74    | 30         | 34         | 19        | 83    |

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(Figure 4). For a description of the different lesions, see Boocock et al. (1995a). A fifth category was added and named “other” according to Sundman and Kjellström (2013a): this includes varied changes indicative of inflammation, such as lobules of bone and clear, irregular thickening of the sinus walls caused by the lamellar bone formation (Sundman & Kjellström, 2013a). For each observable sinus, CMS was scored as either “present” or “absent” based on the presence of at least one of the lesions mentioned above.

To investigate any significant difference in distribution among populations and sex groups, Pearson’s chi-squared test was carried out. A $p$ value ≤0.05 was considered to be statistically significant. Statistical tests were conducted using IBM SPSS Statistics 24 software for Windows.

### 4 | RESULTS

Of the 157 individuals analyzed, 84 (53.5%) showed signs of sinusitis in one or both maxillary sinuses. In both Middenbeemster and Arnhem, CMS seemed to affect the left sinus slightly more frequently than the right one (Table 2).
**TABLE 2** Distribution of bone changes indicative of maxillary sinusitis in individuals within the samples

|                | N  | CMS (%) | CMS right sinus (%) | CMS left sinus (%) |
|----------------|----|---------|---------------------|-------------------|
| Middenbeemster | 74 | 38 (51.3) | 26 (35.1) | 29 (39.2) |
| Arnhem         | 83 | 46 (55.4) | 33 (39.8) | 37 (44.6) |
| Total          | 157| 84 (53.5) | 59 (37.6) | 66 (42.0) |

Abbreviation: CMS, number of individuals with chronic maxillary sinusitis.

**FIGURE 5** Prevalence of chronic maxillary sinusitis (CMS) for both samples under study

5 **DISCUSSION**

Previous bioarchaeological studies have often observed an increased prevalence of bone changes in the maxillary sinuses in urban populations when compared with rural populations, linking CMS to the impoverishment of working and living environments associated with the urbanization of centers and subsequent overcrowding (e.g., Krenz-Niedbał & Łukasik, 2016; Lewis et al., 1995; Sundman & Kjellström, 2013b). However, our results show that CMS was a common condition among individuals from both the rural and urban environments under study. In fact, in both Middenbeemster and Arnhem, more than half of the adult population appears to have been affected...
by sinusitis, showing no statistically significant difference in occurrence rates based on the living environment.

In an extensive study of the prevalence of maxillary sinusitis in skeletons from several archeological sites across the world, Roberts (2007) observed that people who lived in urban settings displayed the highest frequencies of maxillary sinusitis, followed by rural agricultural sites. In an urban setting, pollution, unhygienic conditions, and closely packed housing may have led to an increased susceptibility to sinusitis in populations. As high migration rates in the 18th century caused the inhabitants of Arnhem to live in cramped, unventilated, and unhygienic environments, it is not surprising that most of the population developed skeletal lesions associated with CMS.

In rural agricultural sites, biological particulates in the air (i.e., pollens, molds, and dust produced by agricultural activities) and exposure to pathogens through contact with animals may have all led to inflammation in the sinuses that predisposed to sinusitis (Lewis et al., 1995; May et al., 2012; Roberts, 2007). In the Beemster polder, farms were designed to allow residents to store straw and hay, which likely produced large quantities of dust (de Wit, 2003). The presence of only one chimney in each household and the sharing of living spaces with the cattle during the coldest months likely played an active role in the production of indoor air pollution, therefore increasing CMS rates among the whole population (Aten et al., 2012; de Wit, 2003).

Furthermore, although the type of housing and occupation can lead to different exposures to triggers for sinusitis, in both Middenbeemster and Arnhem, other factors such as climate and weather conditions may have consistently affected people’s health. Today, low temperatures, dampness, and frequent rains are thought to actively influence the occurrence and chronicization of sinusitis (Haines et al., 2006). During the 18th and 19th centuries, problems associated with climate were rather common throughout the whole area today encompassed by the Netherlands: even though the weather started to generally improve in terms of higher temperatures and more rainfall from the 1800 onwards, adverse climatic conditions were still accounted responsible for reduced food production, limited water supply, and increased vulnerability from infectious disease (Wintle, 2000). According to de Meere (1982), these adverse weather conditions were especially hard on farmers and countryside inhabitants, where food production was more bound to good weather and where adequate health care was not always accessible (de Meere, 1982; Wintle, 2000). Although the Beemster area mainly relied on livestock and cheese production, there is no arguing that hard weather conditions may have had an impact on the production of food, potentially leading to increased frailty among residents. In addition to that, frequent rains and generally bad weather conditions likely had an impact on the daily habits of both Middenbeemster and Arnhem individuals: persistent rains and rigid climatic conditions may have impacted the time people spent indoors, as well as the quantity of charcoal burnt to heat up the house. We argue that, although housing and working conditions were overall better in the Beemster area compared with Arnhem, exposure to indoor air pollution and adverse weather conditions may have had an impact on the respiratory health of both communities.

Our second hypothesis was females would have higher rates of sinusitis, as their traditional domestic role constantly exposed them to indoor pollution and dust. However, we observed no significant relationships in the distribution of CMS among males and females at Arnhem nor at Middenbeemster.

In Middenbeemster, both bioarchaeological and historical research have observed a deep gender-based division of labor (Aten et al., 2012; Palmer et al., 2016; Veselka et al., 2013) and therefore led us to expect significant differences in CMS rates based between males and females, based on different exposure to respiratory hazards. Although there is no doubt that women’s domestic role exposed them to indoor pollution and dust, we expected men’s life in the fields to be beneficial for their respiratory health. However, it is possible that spending long hours in the cold and damp countryside, continuously in contact with pollens and cattle may have ended up severely impacting men’s vulnerability, to the point that their CMS rates were similar to women’s.

Although throughout the 19th century Dutch women’s role was traditionally most entirely domestic, in urban realities such as Arnhem, it was common for everyone (i.e., men, women, and children) to be involved in manufacturing production (van Laar, 1966; Wintle, 2000). Working for long hours and without adequate protection nor ventilation constitutes a major risk for respiratory disease. Our results showed no significant differences in the occurrence of CMS among men and women in Arnhem, indicating how their equal exposure to respiratory hazards in the working environment had similar, adverse consequences on their respiratory health.

The major limitation of the study is the limited sample size, which brings into question how representative our sample is of the actual population. Although a larger sample size would have reduced the issue and could potentially represent a valid pathway for future research, Wood et al. (1992), DeWitte and Stojanowski (2015), and others have suggested that no skeletal population will ever be truly representative, as they are composed of the dead. Furthermore, although the relationship between infectious disease and CMS is clinically not yet fully understood, it is possible that precarious living conditions in Arnhem would have predisposed more people to various infectious diseases alongside sinusitis (e.g., tuberculosis and pulmonary disease). Future research on the topic without the selection criteria set in this study could potentially explore the relationship between sinusitis and infectious disease.

Lastly, even if there is a fair abundance of historical data on both Middenbeemster and Arnhem, our interpretation of results is limited by a lack of knowledge about many other aspects of the everyday lives of these individuals and how this may have impacted their respiratory health (Chung & Waterer, 2011; de Oliveira et al., 2019; Visca et al., 2018). Tobacco smoke was likely involved in the spread of respiratory disease in both investigated sites, as it came into fashion among all Dutch social classes around the 17th century (Carroll et al., 2016; Roessingh, 1979). According to WHO (2016), exposure to tobacco smoke (both the active and secondhand) constitutes the major threat to respiratory health. Future research on the relationship between CMS and tobacco smoking at Middenbeemster and Arnhem is underway.
CONCLUSIONS

Our results show that CMS was a common condition among individuals from the Dutch early modern rural and urban contexts of Middenbeemster and Arnhem. Despite previous bioarchaeological research linking higher rates of CMS to urban settlements, we observed no statistically significant relationship between the occurrence of sinusitis and the type of environment under study. In addition, no statistically significant differences were found in sinusitis rates between sex groups. For various historical and social reasons, urban settlements are habitually considered as unhealthy and unhygienic environments in which life is constantly threatened. In contrast to this, both media and the public opinion often refer to rural living as to a hazard-free, open-air existence that would hardly put inhabitants at risk. Instead, this research suggests that living in Middenbeemster did not necessarily constitute a risk-free environment for respiratory disease. Therefore, we argue that each living environment, whether urban or rural, is unique and likely challenges its inhabitants in different ways. In this framework, osteoarchaeology is one of our finest tools to investigate this complex phenomenon. Future research into the respiratory health of early modern populations will undoubtedly benefit from expanding to a wider range of urban and rural skeletal collections from all over Europe for which information such as climate, housing conditions, socioeconomic class, and/or occupational activities is known.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

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