Case report: paleopathology

Behind the wall: A paleopathological examination of a non-adult subject from the cemetery of Santa Maria Maggiore, Vercelli

Arianna Vanni, Roberta Fusco
Department of Biotechnology and Life Science, University of Insubria

Abstract. This study presents the anthropological and paleopathological investigation of Non-adult#1, an infant recovered from Funerary Unit 12 within the church of Santa Maria Maggiore in Vercelli, Italy. Non-adult#1 exhibited skeletal evidence suggestive of scurvy, characterized by diffuse porosity and new bone deposition in various skeletal elements. Through a comprehensive analysis incorporating macroscopic observations, skeletal measurements and cross-referencing with clinical and paleopathological literature, Non-adult#1 was classified as a probable case of scurvy. The interpretation of Non-adult#1's skeletal remains was further complicated by preservation challenges, incomplete mineralization and the fragmentary nature of the assemblage. Despite these complexities, Non-adult#1's pathology offers valuable insights into the health status and societal conditions of individuals in Modern Era northern Italy. This interdisciplinary approach underscores the importance of integrating archaeological, historical, and bioarchaeological perspectives to elucidate the complexities of past human health and well-being.

Key words: vitamin deficiency, scurvy, nonadults, Santa Maria Maggiore

Introduction

Today's church of Santa Maria Maggiore in Vercelli, built around the 1770s, is associated with a previous complex of the same name and the nearby church of the "Santissima Trinità" (Holy Trinity) (Tibaldeschi G, 1996).

After the suppression of the Jesuits, the new ecclesiastic complex is purchased by the Episcopal Curia, which completed the work in 1780, and transferred the dedication and parish dignity from the old basilica of Santa Maria Maggiore (which was demolished in 1776-77) to the new church (Sommo, 2008; Caldano, 2019).

In the years 1777, the underground cemetery is opened for funerary use, accommodating burials; but according to written sources, already from 1775, this place has also been hosting human remains exhumed from the old episcopal complex (Tibaldeschi G, 1996; Fusco et al., 2023; Vanni et al., 2024).

In this article, we will focus on a single Funerary Unit, FU12 (Figure 1), recovered in 2022.

Along the southern perimeter of the church, within the central sector (III), FU12 is located inside a compartment created behind the wall and identified externally by a buffered arch (Vanni et al., 2024). This burial was identified due to the presence of a breach (61cm wide and 40cm high) and consists of a wooden coffin, smaller in size than the compartment, which, in turn, does not have the same dimensions as the arch. Due to the narrow width of the breach, it was not possible to recover the coffin or take precise measurements (Figure 1.c), however, the burial space inside the arch is approximately 70cm high and 91cm wide (Bettin, 2022).

Around 400 intermingled bone fragments were found in this ossuary, 46 of which belonged to non-adult individuals.

The bones and districts were not arranged anatomically, except for two skulls with evidence of

Figure 1. a. Planimetry of Santa Maria Maggiore: in the red circle Funerary Unit 12, Sector III. b. FU12 (Bettin, 2022). c. Detail of FU12.

craniotomies positioned exactly at the feet of the coffin (see Vanni et al., 2024), suggesting a secondary deposition.

The overall preservation state of the bones was good. However, what stands out from the study of the ossuary is the limited representation of many districts, such as the spinal column, ribs, hands and feet.

Considering the tibiae, a minimum number of 11 adult individuals was established, whereas concerning the non-adults, there were 6 individuals, reconstructed by studying the lengths of bone districts, dental eruption, and epiphyseal fusion ages, thereby assigning the bones to each individual according to the age.

Here we present the anthropological and paleopathological study of one of the non-adults from FU12, denominated Non-adult#1.

Materials and Methods

Non-adult#1 is the individual upon which we will focus our observations. As previously mentioned, this individual was not arranged in an anatomical position, but first it was necessary to study all the non-adult bone remains to assign them to an individual (as seen in Giuffra et al., 2015).

The subject, as visible in Figure 2, consists of a mandible, scapulae, humeri, right ulna, femurs, and tibias, all in a good preservation state.

The age at death was estimated based on long bones length (Maresh, 1970; Ubelaker, 1989; Scheuer & Black, 2000), scapulae measurements (Saunders et al., 1993), degree of fusion of bone diaphysis and epiphysis (Minozzi & Canci, 2015) and dental eruption (Ubelaker, 1989).

Individuals have been classified following the age classes proposed by Buikstra and Ubelaker (1994) as stillbirths (< 0 years), infants (0–3 years), and children (≥ 4 years) (Buikstra & Ubelaker, 1994).

Macroscopic observations were conducted using the naked eye and a magnifying glass.

Bone anomalies, identified as potential pathologies, were cross-referenced with clinical and paleopathological literature (Ortner & Ericksen, 1997; Ortner & Mays, 1998; Ortner D, 2003; Brickley & Ives, 2006; Lewis et al., 2006; Mays et al., 2006; Mays, 2008; Geber & Murphy, 2012; Schattmann et al., 2016; Brickley et al., 2018; Buikstra, 2019; Brickley et al., 2020).

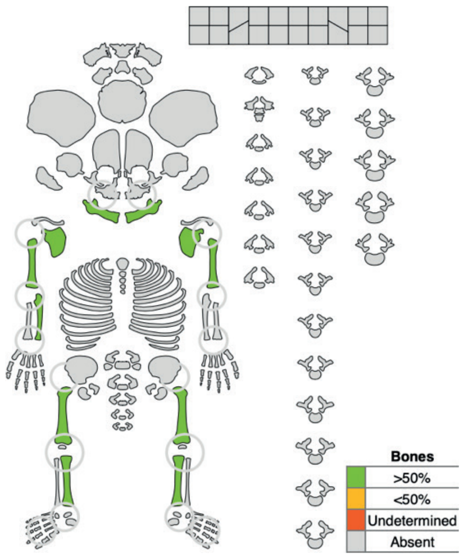

Figure 2. Graphic reconstruction of the degree of preservation of bone districts. Made with HumanOS (https://www.humanos.cnrs.fr).

Photographic data has been taken with a Fecamos digital microscope (1000x magnification), along with high-magnification photographic images using a Canon 50D camera with Laowa Venus Lens 60mm f2.8 2:1.

The diagnostic criteria encompass pathological changes such as abnormal porosity, new bone formation in both cranial and postcranial bones, lytic phenomena, morphological variations (e.g., bowing of long bones, flaring), growth plate alterations, and fractures (Ortner & Ericksen, 1997; Ortner & Mays, 1998; Ortner et al., 1999; Ortner et al., 2001; Ortner, 2003; Brickley & Ives, 2006; Lewis et al., 2006; Mays et al., 2006; Mays, 2008; Geber & Murphy, 2012; Schattmann et al., 2016; Brickley et al., 2018; Snoddy et al., 2018; Buikstra, 2019; Brickley et al., 2020). Each trait was assigned one of the following scores: probable, possible, non-diagnostic, or under evaluation (Schattmann et al., 2016). For each individual, it was assessed whether the characteristic was present, absent, or impossible to evaluate due to lack, incompleteness, or damage to the district (Schattmann et al., 2016).

Individuals were then classified as cases of scurvy and/or rickets: probable (if two or more probable features or three or more possible features), possible (if three or more possible features and others non-diagnostic), inconclusive due to insufficient data, or co-occurrence (when the subject is found to be a possible or probable case for both pathologies) (Schattmann et al., 2016).

Results

Non-adult#1 belonged to the age group corresponding to an infant, based on the diaphyseal length of humeri, left ulna, femurs and tibias and on dental eruption.

The mandible shows diffuse porosity with a diameter smaller than 1mm, both at the level of the mandibular foramina and along the alveolar margins, as well as slight neo-osseous deposition, as can be appreciated from Figure 3.a.

Both scapulae at the level of the supraspinous fossa symmetrically show diffuse porosity with a diameter smaller than 1mm and some scattered pores of larger diameter. Along the spine, symmetrically, there is also neo-osseous deposition, as can be seen in Figure 3.b and in Table 1.

Discussion

Discovering widespread porosity and new bone deposition led to the evaluation of possible pathology and subsequently to hypothesizing its etiology in the individual under study.

Before being able to distinguish nutritional deficiencies affecting the bone, it is important to remember that this is a metabolically active tissue that requires a balance and homeostatic control of micronutrients, including minerals and vitamins (de Boer & Van der Merwe, 2016; D'Ortenzio et al., 2016; Meyer, 2016; Thaler et al., 2022). When this balance is disrupted, it is generally referred to as "metabolic bone disease" and specifically, if the triggering cause is a dietary-related deficiency of vitamins or minerals, it will be termed "nutritional deficiency" (Meyer, 2016).

The observed porosity and new bone deposition led to an evaluation of possible pathology, with considerations for metabolic bone diseases such as scurvy

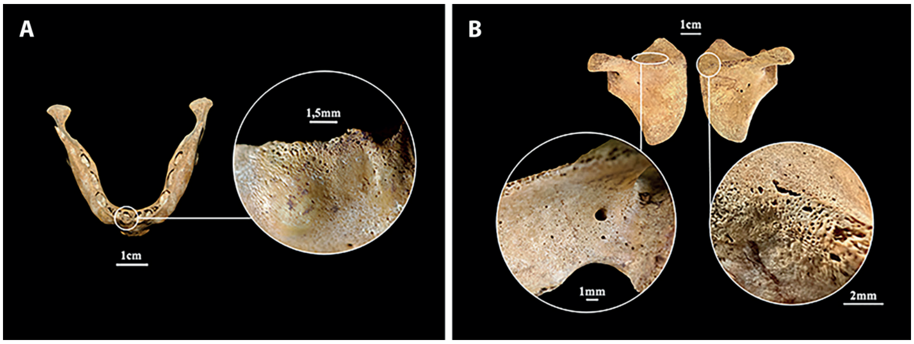

Figure 3. a. Porosity and new bone formation around alveolar processes with magnification of the highlighted area; b. Supraspinous porosity highlighted in the left circle; spinous line neo-deposition (right circle).

and rickets. The data were collected in a table listing the pathological traits related to these diseases identified in previous works (Mays et al., 2006; Schattmann et al., 2016; Snoddy et al., 2018).

For the differential diagnosis, we considered those pathologies that exhibit skeletal lesions and characteristics similar to those caused by scurvy and rickets. Among these pathologies, we must mention anemia, which, at the skeletal level, also manifests as general thinning of compact bone tissue, thickening of the diploe, flaring of the metaphysis and scattered pores in the orbital cavity. With the progression of the disease, these features may appear as *enlarged or linked trabeculae* (Brickley & Ives, 2006; Larentis et al., 2023; Ribot & Roberts, 1996; Zuckerman et al., 2014). In the study subject, however, these features, of the retrieved bones, do not seem to be indicative of anemia. It is important to note, though, that iron-deficiency anemia can co-occur with both scurvy and rickets (Brickley et al., 2018; Stark, 2014).

Congenital syphilis can also be ruled out because it is characterized by limb deformities and new bone deposition, however, we have not found these features (Giuffra et al., 2015; Larentis et al., 2020, 2023). As for leukemia, which is characterized by bone resorption and erosion, especially in the metaphysis of long bones, our sample shows cortical erosion in almost all fragments, but this is due to a taphonomic process, which we will discuss shortly (Larentis et al., 2023).

Finally, avitaminosis C and D can co-occur, meaning they can be present simultaneously. Dietary deficiencies often do not involve only a single vitamin or mineral (Meyer, 2016). In the co-occurrence of scurvy and rickets an inhibitory interaction is established: scurvy limits collagen production and the accumulation of non-mineralized osteoid, thereby impeding the development of characteristic abnormal curvatures caused by rickets; rickets, in turn, inhibits the neo-deposition of bone matrix (Brickley & Mays, 2019; Schattmann et al., 2016; Stark, 2014). For our sample, this hypothesis is not supported by the observations made, as there are no common features between the two vitamin deficiencies, especially those typical of rickets, such as the bowing of long bones, deformation of the femoral neck (coxa vara) and of mandibular condyles.

Non-adult#1 exhibits two probable characteristics and one possible trait for scurvy and, based on the evaluation system described earlier, is a probable case of scurvy.

However, the presence of porosity is not a conclusive indicator of a specific metabolic disease. This cribrosity, especially at the cranial and epiphyseal levels, may not only be associated with other pathologies but could also be confused with normal porosity linked to growth in nonadults, even though it does not penetrate the cortical bone (Brickley & Mays, 2019; Brickley & Ives, 2006; Ribot & Roberts, 1996; Snoddy et al., 2018).

The 6 nonadults of FU12 were indeed in an ossuary chest with approximately 9 adult individuals, placed behind a perimeter wall of the cemetery. The

Table 1. Shows the macroscopic paleopathological observations.

	Diagnostic category [b]	**Non-adult#1**
Scurvy		
Sphenoid: Greater Wing [P, N]	PR	-
Sphenoid: Lesser wing [P]	PO	-
Sphenoid: Foramen rotundum [P]	PO	-
Orbit: Internal zygomatic [P]	PO	-
Endocranium [P,N]	ND	-
Maxilla: Posterior [P]	PR	-
Maxilla: Infraorbital foramen [P, N]	PO	-
Maxilla: Palate [P]	ND	-
Maxilla: Alveolar process [P,N]	ND	**P**
Mandible: Medial coronoid [P,N]	PO	**P**
Mandible: Alveolar process [P]	ND	**P**
Scapula: Supraspinous [P,N]	PR	**P**
Scapula: Infraspinous [P,N]	PR	**P**
Ilium [P]	ND	-
New bone: Arms	ND	**A**
New bone: Legs	ND	**A**
Rickets		
Frontal bone bossing	ND	-
Deformed mandibular ramus	PO	**A**
Rib deformity (sharp angle)	PO	-
Ilium concavity	PO	-
Abnormal growth plate: Score 2 [c]	PR	**A**
Abnormal growth plate: Score 3 [c]	PR	**A**
Abnormal growth plate: Score 4 [c]	PR	**A**
Long bone concave curvature porosity	PO	**A**
Flattening of the femoral metaphysis & coxa vara	PR	**A**
Thickened long bones	PR	**A**
Shared features of scurvy and rickets		
Cranial vault [P]	ND	-
Cranial vault [N]	ND	-
Orbital roof [P, N]	ND	-
Rib: Fracture(s) on the sternal growth plate	PO	-
Rib: Flaring	PO	-
Rib: Porosity	ND	-
Long bone metaphyseal flaring: Arm	PO	**A**
Long bone metaphyseal flaring: Leg	PO	**A**
Metaphyseal porosity: Arms	ND	**P**
Metaphyseal porosity: Legs	ND	**P**
Other features		
Pars basilaris [c P]	UE	-

Abbreviations: P, present; A, absent; - not recorded due to skeletal part missing or damaged; P, porosity; N, new bone formation; PR, probable; PO, possible, ND, non-diagnostic; UE, under evaluation; c scale by Mays et al. (2006).

burial area of Santa Maria Maggiore hosts inhumations of the people who belonged to the parish, ecclesiastics and representatives of the noble class of Vercelli, still, it also includes remains that were originally interred in the ancient church of Santa Maria Maggiore (Garanzini et al., 2023; Licata et al., 2024; Vanni et al., 2024; Vanni & Fusco, 2023). Historical data do not allow us to identify the origin of FU12, but the presence in a single chest of multiple individuals belonging to different age groups could suggest membership of a family, possibly a chapel previously allocated in the old co-cathedral.

This translation would imply the exhumation of the bodies and their relocation into the coffin, which likely resulted in the loss, primarily, of some bone districts.

It is important to acknowledge that discerning potential diseases in skeletal remains can be challenging due to the condition of preservation; completeness and integrity are indeed critical factors to consider.

The fragmentary nature of the remains, not only of the subject we studied but also of the other non-adult individuals recovered, has limited the possibility of collecting data (for example, none of the individuals have preserved sphenoid bones, possibly due to taphonomic factors or burial translocation) and reaching a more exhaustive description of the sample.

The challenging preservation of nonadult remains is primarily linked to the incomplete mineralization of bone tissue, characterized intrinsically by greater porosity and subsequently to the characteristics of the surrounding environment (physical-chemical conditions, especially its acidity) (Guy et al., 1997; Scheuer & Black, 2000). FU12, considering the adult sample as well, indeed presents many severely damaged superficial bone districts, with extensive exposure of spongy tissue and cortical erosion, possibly indicating an environment particularly unfavorable to preservation.

In light of these observations, interpreting this individual is not straightforward.

The other 5 non-adults are mostly represented by few bone districts, often severely damaged, yet they do not seem to exhibit signs of deficiencies.

Even though we do not have written sources, we can hypothesize a dating of the individuals of FU12 roughly between the seventeenth and eighteenth century, based on the possible dating of the craniotomies, also found in the FU12, but also before the demolition of the old complex of Santa Maria Maggiore (1776-77) (Vanni et al., 2024).

From the context, we cannot definitively hypothesize a kinship between the individuals buried in FU12; however, it is notable that Non-adult#1 appears to be the only subject showing osteological evidence of a deficiency pathology. Furthermore, another piece of information regarding the family, to which the remains might belong, derives from the very position of the burial, which can be described as privileged, indicating an affluent condition of the family.

As highlighted by some studies (e.g. Brickley et al., 2014; Giuffra et al., 2015), vitamin deficiencies should be considered in conjunction with the community context. In this case, Non-adult#1 appears to belong to an affluent class.

The discussion of scurvy's historical epidemiology unveils a multifaceted narrative encompassing maternal and neonatal factors, nutritional demands of growth, disease predisposition and weaning practices (Brickley & Mays, 2019). Neonatal levels of vitamin C, intricately linked to maternal levels and present in breast milk, underscore the critical role of maternal nutrition in preventing early-onset scurvy in infants (Brickley & Mays, 2019). Scurvy's rarity before four months, except in cases of maternal deficiency, highlights the dependence on maternal stores during the early postnatal period (Brickley & Mays, 2019). This dependence gradually diminishes as infants transition to complementary foods, marking a critical phase vulnerable to nutritional deficiencies.

The demands of growth accelerate the onset of scurvy symptoms in children, with the condition commonly observed between 5–24 months, peaking between 8–11 months (Brickley & Ives, 2006). This period aligns with the transition from exclusive breastfeeding to a mixed diet. Moreover, the vulnerability to scurvy extends beyond infancy, with reports of the disease becoming increasingly prevalent even in apparently healthy children due to underlying neurological, psychiatric, renal, and malabsorptive conditions (Trapani et al., 2022). This underscores the importance of considering broader health factors beyond mere dietary intake in assessing susceptibility to scurvy.

Archaeological evidence further illuminates the impact of weaning practices on child health and mortality. Peak subadult mortality during the weaning period suggests a vulnerability to infectious diseases and malnutrition associated with the transition to supplementary foods (Novak et al., 2018).

Sporadic outbreaks in large armies since Roman times and civilian populations during times of famine underscore the vulnerability of populations to nutritional deficiencies. Historical outbreaks of scurvy, documented in French charities during the late 16th and early 17th centuries, highlight the recognition of dietary deficiencies and the role of fresh milk and mashed potatoes in combating the disease (Magiorkinis et al., 2011).

However, historical references to infantile scurvy remain scarce prior to the 19th century, raising questions about its prevalence or recognition (Mays, 2014).

As for rickets and osteomalacia, evidence suggests that biological, environmental, and sociocultural factors affecting vitamin D metabolism, including disorders of the gut, liver and kidney, have contributed to the prevalence of the pathology in different populations (Resnick & Niwayama, 1988). Cultural practices such as indoor lifestyles, clothing habits, and urbanization have significantly impacted sunlight exposure, a key determinant of rickets prevalence, thereby influencing the frequency of rickets within populations (Brickley et al., 2014).

Archaeological investigations have provided valuable insights into the temporal and spatial distribution of rickets, revealing its presence in human populations dating back to prehistoric times and also in ancient civilizations such as the Romans (Bennike, 1985; Blondiaux et al., 2002). But the incidence of this disease appears to have increased dramatically in post-medieval urban industrialized groups, reaching frequencies of up to approximately 34% in some cases (Brickley & Ives, 2006; Clevis & Constandse-Westermann, 1992; Ellis, 2014; Henderson et al., 2013). This rise in prevalence has been attributed to a combination of factors, including changes in lifestyle, cultural practices such as swaddling infants, and environmental conditions in urban settings that limit sunlight exposure (Littleton, 1998; D. Ortner & Mays, 1998; Veselka et al., 2015).

Moreover, age and developmental factors play a significant role in the manifestation of rickets, with the disease rarely appearing before four months of age and cases rarely developing after four years (Maiyegun et al., 2002).

Overall, the historical epidemiology of rickets underscores the importance of considering the intricate interplay between biological, environmental, and sociocultural factors in understanding the prevalence and distribution of this disease throughout history.

However, assuming that FU12 belonged to a single family, why did the other 5 non-adults not seem to suffer from it? If they were members of the same family unit, they would all likely exhibit similar features, following the same diet and receiving the same parental care. The etiology of the disease may therefore not be solely related to the diet; genetic factors or pathologies leading to the malabsorption of micronutrients could also have been involved.

Conclusions

Non-adult#1 reveals osteological evidence suggestive of scurvy, notably amidst what seems to be a privileged social class of the Modern Era (presumably 17^{th} – 18^{th} century). The presence of such pathology prompts questions about the broader societal and familial context, suggesting that factors beyond mere diet could be at play, such as physical disabilities, renal diseases, gastrointestinal malabsorption, infections of parasites, diarrhea but also genetic predisposition. Additionally, the complex interplay of preservation challenges and historical contexts complicates our interpretations, underscoring the need for interdisciplinary approaches in archaeological research. As we continue to unravel the mysteries of the past, each discovery like FU12 offers a glimpse into the lives, health, and societal structures of bygone eras, enriching our understanding of human history.

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References

Bennike, P. (1985). *Palaeopathology of Danish skeletons*. Akademisk Forlag, Copenhagen.

Bettin, S. (2022). *Archeologia e antropologia fisica a Santa Maria Maggiore di Vercelli* [Corso di Laurea Triennale in Lettere]. Università del Piemonte Orientale.

Blondiaux, G., Blondiaux, J., Secousse, F., Cotten, A., Danze, P. M., & Flipo, R. M. (2002). Rickets and child abuse: the case of a two year old girl from the 4th century in Lisieux (Normandy). *International Journal of Osteoarchaeology*, *12*(3), 209–215. https://doi.org/10.1002/OA.616

Brickley, M. B., & Mays, S. (2019). Metabolic Disease. In J. E. Buikstra (Ed), *Ortner's Identification of Pathological Conditions in Human Skeletal Remains*, (pp. 531–566). Elsevier Science Publishing Co Inc. https://doi.org/10.1016/B978-0-12-809738-0.00015-6

Brickley, M. B., Mays, S., George, M., & Prowse, T. L. (2018). Analysis of patterning in the occurrence of skeletal lesions used as indicators of vitamin D deficiency in subadult and adult skeletal remains. *International Journal of Paleopathology*, *23*, 43–53. https://doi.org/10.1016/j.ijpp.2018.01.001

Brickley, M. B., Moffat, T., & Watamaniuk, L. (2014). Biocultural perspectives of vitamin D deficiency in the past. *Journal of Anthropological Archaeology*, *36*(1), 48–59. https://doi.org/10.1016/j.jaa.2014.08.002

Brickley, M., & Ives, R. (2006). Skeletal manifestations of infantile scurvy. *American Journal of Physical Anthropology*, *129*(2), 163–172. https://doi.org/10.1002/ajpa.20265

Brickley, M., Ives, R., & Mays, S. (2020). *The Bioarchaeology of Metabolic Bone Disease*. Academic Press, Cambridge. https://doi.org/10.1016/B978-0-08-101020-4.00012-4

Buikstra, J. E. (2019). *Ortner's Identification of Pathological Conditions in Human Skeletal Remains*. Academic Press, Cambridge.

Buikstra, J. E., & Ubelaker, D. (1994). *Standards for data collection from human skeletal remains.* . Arkansas Archeological Survey, Fayetteville.

Caldano, S. (2019). Un cantiere per un capitolo canonicale di prestigio: Santa Maria Maggiore di Vercelli nel XII secolo. *Arte Lombarda*, *186/187*(2–3), 71–84.

Clevis, H., & Constandse-Westermann, T. S. (1992). *De doden vertellen : opgraving in de Broerenkerk te Zwolle 1987-88*. Stichting Archeologie Ijssel, Kampen.

de Boer, H. H. H., & Van der Merwe, A. E. L. (2016). Diagnostic dry bone histology in human paleopathology. *Clinical Anatomy*, 29(7), 831–843. https://doi.org/10.1002/ca.22753

D'Ortenzio, L., Ribot, I., Raguin, E., Schattmann, A., Bertrand, B., Kahlon, B., & Brickley, M. (2016). The rachitic tooth: A histological examination. *Journal of Archaeological Science*, *74*, 152–163. https://doi.org/10.1016/j.jas.2016.06.006

Ellis, M. A. B. (2014). A Disciplined Childhood in Nineteenth-Century New York City: A Social Bioarchaeology of the Subadults of the Spring Street Presbyterian Church. *Tracing Childhood*, 139–156. https://doi.org/10.5744/FLORIDA/9780813049830.003.0008

Fusco, R., Messina, C., Tesi, C., & Vanni, A. (2023). "Capta est ne malitia mutaret intelletum eius." Study on a natural mummy from an underground cemetery (18-19th century). Medicina Historica, 7(2), e2023044. Retrieved from https://mattioli1885journals.com/index.php/MedHistor/article/view/15140

Garanzini, F., Destefanis, E., Fusco, R., & Licata, M. (2023). Vercelli. Chiesa concattedrale di S. Maria Maggiore. Indagini bioarcheologiche. *Notiziario Della Soprintendenza Archeologia Belle Arti e Paesaggio per Le Province Di Biella Novara Verbano-Cusio-Ossola e Vercelli*, *7*, 114–118.

Geber, J., & Murphy, E. (2012). Scurvy in the Great Irish Famine: Evidence of Vitamin C Deficiency From a Mid-19th Century Skeletal Population. *American Journal of Physical Anthropology*, *148*(4), 512–524. https://doi.org/10.1002/AJPA.22066

Giuffra, V., Vitiello, A., Caramella, D., Fornaciari, A., Giustini, D., & Fornaciari, G. (2015). Rickets in a High Social Class of Renaissance Italy: The Medici Children. *International Journal of Osteoarchaeology*, *25*(5), 608–624. https://doi.org/10.1002/oa.2324

Guy, H., Masset, C., & Baud, C. A. (1997). Infant taphonomy. *International Journal of Osteoarchaeology*, *7*, 221–229.

Henderson, C., Evans-Lacko, S., & Thornicroft, G. (2013). Mental Illness Stigma, Help Seeking, and Public Health Programs. *American Journal of Public Health*, *103*(5), 777–780. https://doi.org/10.2105/AJPH.2012.301056

Larentis, O., Licata, M., Tonina, E., & Pangrazzi, C. (2023). Probable micronutrient deficiency diseases in a rural community. The nonadults of Mary's Nativity church, 16th century, Trentino Alto-Adige, Italy. *Journal of Archaeological Science: Reports*, *47, 103774*. https://doi.org/10.1016/j.jasrep.2022.103774

Larentis, O., Tonina, E., Iorio, S., Gorini, I., & Licata, M. (2020). Osteological evidence of metabolic diseases from a post medieval North Italy archaeological site. *Journal of Maternal-Fetal and Neonatal Medicine*, *33*(16), 2735–2742. https://doi.org/10.1080/14767058.2018.1560405

Lewis, D., Carpenter, C., Evans, A., & Thomas, P. (2006). Rickets and Scurvy presenting in a Child as apparent Non Accidental Injury. *The Internet Journal of Orthopedic Surgery*, *4*(2). https://doi.org/10.5580/119D

Licata, M., Tesi, C., Larentis, O., Destefanis, E., Garanzini, F., Ciliberti, R., & Fusco, R. (2024). Elongated styloid process of an autopsied skull from the Cemetery of Santa Maria Maggiore in Vercelli, 18th–19th century (Piedmont, northern Italy). *Anthropologischer Anzeiger*, 81(2), 209–218. https://doi.org/10.1127/ANTHRANZ/2023/1671

Littleton, J. (1998). A middle eastern paradox: rickets in skeletons from Bahrain. *Journal of Paleopathology*, *10*, 13–30.

Magiorkinis, E., Beloukas, A., & Diamantis, A. (2011). Scurvy: Past, present and future. *European Journal of Internal Medicine*, *22*(2), 147–152. https://doi.org/10.1016/J.EJIM.2010.10.006

Maiyegun, S. O., Malek, A. H., Devarajan, L. V., & Dahniya, M. H. (2002). Severe congenital rickets secondary to maternal hypovitaminosis D: A case report. *Annals of Tropical Paediatrics*, *22*(2), 191–195. https://doi.org/10.1179/027249302125000940

Maresh, M. M. (1970). Measurements from Roentgenograms. In R. W. McCammon (Ed.), *Human Growth and Development* (pp. 157–200). C.C. Thomas, Springfield.

Mays, S. (2008). A likely case of scurvy from early Bronze Age Britain. *International Journal of Osteoarchaeology*, *18*(2), 178–187. https://doi.org/10.1002/OA.930

Mays, S. (2014). The palaeopathology of scurvy in Europe. *International Journal of Paleopathology*, *5*, 55–62. https://doi.org/10.1016/j.ijpp.2013.09.001

Mays, S., Brickley, M., & Ives, R. (2006). Skeletal manifestation of rickets in infants and young children in a historic population from England. *American Journal of Physical Anthropology*, *129*(3), 362–374. https://doi.org/10.1002/ajpa.20292

Meyer, A. (2016). Assessment of diet and recognition of nutritional deficiencies in paleopathological studies: A review. *Clinical Anatomy*, 29(7), 862–869. https://doi.org/10.1002/ca.22696

Minozzi, S., & Canci, A. (2015). *Archeologia dei resti umani. Dallo scavo al laboratorio*. Carocci Editore, Roma.

Novak, M., Vyroubal, V., Krncevic, Z., Petrinec, M., Howcroft, R., Pinhasi, R., & Slaus, M. (2018). Assessing childhood stress in early mediaeval Croatia by using multiple lines of inquiry. In *Anthropologischer Anzeiger,* 75(2), 155–167. https://doi.org/10.1127/anthranz/2018/0819

Ortner, D. (2003). *Identification of pathological conditions in human skeletal remains.* Academic Press, Cambridge.

Ortner, D., & Ericksen, M. F. (1997). Bone changes in the human skull probably resulting from scurvy in infancy and childhood. *International Journal of Osteoarchaeology*, 7, 212–220.

Ortner, D. J., Butler, W., Cafarella, J., & Milligan, L. (2001). Evidence of probable scurvy in subadults from archeological sites in North America. *American Journal of Physical Anthropology*, *114*(4), 343–351. https://doi.org/10.1002/ajpa.1046

Ortner, D. J., Kimmerle, E. H., & Diez, M. (1999). Probable Evidence of Scurvy in Subadults From Archeological Sites in Peru. *American Journal of Physical Anthropology*, *108*, 321–331. https://doi.org/10.1002/(SICI)1096-8644(199903)108:3

Ortner, D., & Mays, S. (1998). Dry-bone manifestations of rickets in infancy and early childhood. *International Journal of Osteoarchaeology*, 8, 45–55.

Resnick, D., & Niwayama, G. (1988). *Diagnosis of Bone and Joint Disorders*. Saunders, Philadelphia.

Ribot, I., & Roberts, C. (1996). A Study of Non-specific Stress Indicators and Skeletal Growth in Two Mediaeval Subadult Populations. *Journal of Archaeological Science*, *23*(1), 67–79. https://doi.org/10.1006/JASC.1996.0006

Saunders, S., Hoppa, R., & Southern, R. (1993). Diaphyseal growth in a nineteenth century skeletal sample of subadults from St Thomas' church, Belleville, Ontario. *International Journal of Osteoarchaeology*, *3*(4), 265–281. https://doi.org/10.1002/OA.1390030405

Schattmann, A., Bertrand, B., Vatteoni, S., & Brickley, M. (2016). Approaches to co-occurrence: Scurvy and rickets in infants and young children of 16-18th century Douai, France. *International Journal of Paleopathology*, *12*, 63–75. https://doi.org/10.1016/j.ijpp.2015.12.002

Scheuer, Louise., & Black, S. M. (2000). *Developmental juvenile osteology*. Academic Press, Cambridge.

Snoddy, A. M. E., Buckley, H. R., Elliott, G. E., Standen, V. G., Arriaza, B. T., & Halcrow, S. E. (2018). Macroscopic features of scurvy in human skeletal remains: A literature synthesis and diagnostic guide. *American Journal of Physical Anthropology*, *167*(4), 876–895. https://doi.org/10.1002/ajpa.23699

Sommo, G. (2008). *Vercelli e la memoria dell'antico. Schede e documenti per un approccio alla storia ed ai problemi dell'archeologia, della tutela e conservazione in un centro della provincia piemontese*. Edizione elettronica archeovercelli.it. Gruppo Archeologico Vercellese.

Stark, R. J. (2014). A proposed framework for the study of paleopathological cases of subadult scurvy. *International Journal of Paleopathology*, *5*, 18–26. https://doi.org/10.1016/j.ijpp.2014.01.005

Thaler, R., Khani, F., Sturmlechner, I., Dehghani, S. S., Denbeigh, J. M., Zhou, X., Pichurin, O., Dudakovic, A., Jerez, S. S., Zhong, J., Lee, J. H., Natarajan, R., Kalajzic, I., Jiang, Y. hui, Deyle, D. R., Paschalis, E. P., Misof, B. M., Ordog, T., & van Wijnen, A. J. (2022). Vitamin C epigenetically controls osteogenesis and bone mineralization. *Nature Communications*, *13*(1), 5883. https://doi.org/10.1038/s41467-022-32915-8

Tibaldeschi G. (1996). La Chiesa di S. Maria Maggiore di Vercelli e l'Assunzione di Paolo Borroni. *Bollettino Storico Vercellese*, *2*, 131–150.

Trapani, S., Rubino, C., Indolfi, G., & Lionetti, P. (2022). A Narrative Review on Pediatric Scurvy: The Last Twenty Years. In *Nutrients*, 14(3), 684. https://doi.org/10.3390/nu14030684

Ubelaker, D. H. (1989). *Human Skeletal Remains: Excavation, Analysis, lnterpretation.* Taraxacum.

Vanni, A., & Fusco, R. (2023). Companions in eternity. The historical practice of burying pets. In *Journal of Bioarchaeological Research,* 1(3), e2023023. Retrieved from https://www.mattioli1885journals.com/index.php/JBR/article/view/15466

Vanni, A., Fusco, R., Tesi, C., & Licata, M. (2024). Autopsy or anatomical dissection? Comparative analysis of an osteoarchaeological sample from an 18-19th century hypogeal cemetery (northern Italy). *Journal of Archaeological Science: Reports*, *54*, 104418. https://doi.org/10.1016/j.jasrep.2024.104418

Veselka, B., Hoogland, M. L. P., & Waters-Rist, A. L. (2015). Rural Rickets: vitamin D deficiency in a post-medieval farming community from the Netherlands. *International Journal of Osteoarchaeology*, *25*, 665–675.

Zuckerman, M. K., Garofalo, E. M., Frohlich, B., & Ortner, D. J. (2014). Anemia or scurvy: A pilot study on differential diagnosis of porous and hyperostotic lesions using differential cranial vault thickness in subadult humans. *International Journal of Paleopathology*, *5*, 27–33. https://doi.org/10.1016/j.ijpp.2014.02.001

Correspondence:
Arianna Vanni
Department of Biotechnology and Life Science, University of Insubria
E-mail: arianna.vanni@uninsubria.it