Bioarchaeology and Dietary Reconstruction across Late Antiquity and the Middle Ages in Tuscany, Central Italy

Giulia Riccomi

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Cover: Burial T. 59. Child deposed in enchytrismòs (4th -5th centuries AD) from the urban necropolis of Via Marche (Pisa, Italy) (from Paribeni, Cerato, Costantini, Ghizzani Marcìa, Mileti, & Rizzitelli, 2012, Via Marche/Via Abba-Scavo preventivo (Dataset), Pisa: MOD doi:10.4456/MAPPA.2012.28)
Back Cover: Pava'08 US 8432. Mild form of linear enamel hypoplasia affecting the left mandibular canine ad premolars (© G. Riccomi).

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Foreword

The period spanning Late Antiquity (3rd to 5th century AD) to the Middle Ages (6th to 15th century AD) has long left its mark on the historical consciousness of Europe. In particular, there has been considerable debate as to what happened to social, economic, and political organisation in different regions following the collapse of the Western Roman Empire. Although earlier research, popular sources, and public consciousness can paint the picture of a world plunged into 'darkness', often echoing our own fears of what the future might hold for western societies in the 21st century, growing academic work over the last two decades has increasingly revealed the dynamic and innovative forms of agriculture, settlement, long-distance exchange and trade, and political control that emerged in Europe following the end of the Classical period.

Such lines of enquiry have been especially intense in Italy, as the former heart of one of the largest empires ever to have existed and the geographical area that perhaps had the most to lose following the abandonment of the classical Roman imperial structure. In rural areas, it has been suggested that there was a widespread abandonment of rural Roman *villae* that had provided the key model of agrarian food production. Other scholars have described the complete depopulation of most of the Italian countryside. Nevertheless, more recently, historians and archaeologists have argued that there was actually rather a gradual reconfiguration of the relationship between urban and rural realms, with local independence leading to diverse, context-specific, resilient agricultural adaptations during the Early Middle Ages.

Testing these scenarios has been challenging due to a lack of direct methodologies for determining how local communities practically experienced wider social, political, and economic changes. Literary sources and archival records have been frequently relied upon, and have noted changes in demography, hierarchical access to resources, and culinary practices – although they are often sparse and only relate to certain, often elite, sectors of society. Detailed osteoarchaeology and biomolecular methodologies, such as stable isotope analysis, have been shown to have immense promise of directly studying the diet, nutrition, and experiences of individuals in the past, including in the Classical period and the Middle Ages. However, diachronic studies, from Classical to post-Classical times, have rarely been attempted within Italian bioarchaeology. Furthermore, only a few studies address the consequences of sociocultural transitions for living conditions viewed through multiple skeletal and dental stress markers.

From this perspective, the volume based on the PhD thesis of Dr. Giulia Riccomi represents a major step forward. In it the author applies a multidisciplinary framework to human remains excavated from Late Antiquity (3rd-5th centuries AD) and the Middle Ages (mid 6th-mid 13th centuries AD) funerary contexts from the three sites of Via Marche, v*icus Wallari/borgo San Genesio*, and Pieve di Pava in Tuscany, central Italy. By reconstructing detailed insights into human dietary reliance on different food groups and changes in skeletal stressors and markers of health between the two time periods, between rural and urban contexts, and between social groupings for the first time, the study provides novel data relating to the actual human implications of social, economic, and political reconfiguration among communities living at the core of a vast empire.

The osteoarchaeological research demonstrates that there may actually have been an improvement in living conditions in this part of rural Italy between Late Antiquity and the Middle Ages, in terms of longer life expectancy for individuals and an increased male stature. Other skeletal stress markers, such as *cribra orbitalia* and periosteal reaction show no clear pattern of change, but certainly no clear evidence for a shift towards an impoverished 'Dark Ages'. Similarly, linear enamel hypoplasia reveals no diachronic discrepancy in terms of prevalence between the two periods, although the age of onset of the defects seems to suggest different 'weaning' practices. Meanwhile, the stable isotope data shows evidence for a growing inclusion of millet, alongside wheat, in human diets, as well as regional variability, something the author interprets as part of a growing diversity of locally-resilient agricultural systems and cultural preferences during the Middle Ages.

While Dr. Riccomi notes that there are some limitations of the study, including imbalanced temporal representation of urban and rural contexts and potential sample size issues for making inferences at the population level, the results, as she notes, allow us to begin to 'explore the ways in which communities perceived and reacted to change during the passage to post-Classical times in the Mediterranean area…'. As well as crucial, novel data, the study, performed by a scholar who has practical and theoretical experience in two very different skillsets, provides an important model for the type of integrated multidisciplinary research that can begin to elucidate the health, cultures, and economic experiences of the varied communities navigating the post-Classical European world, contributing to a broader discussion of living conditions in the Mediterranean of the 1st millennium AD.

Patrick Roberts
Research Group Leader
Max Planck Institute for the Science of Human History, Jena, Germany
email: roberts@shh.mpg.de

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UNIVERSITÀ DI PISA MAX-PLANCK-GESELLSCHAFT divisione di paleopatologia ANTHROPOLOGY UC BERKELEY

I. Introduction

1.1 Area of research: bioarchaeology and the concept of 'stress'

Bioarchaeology is a relatively young research field that emerged during the 1960s from the application of skeletal biology to the paradigms of American processual archaeology (i.e. the New Archaeology) and cultural ecology (Buikstra 1977; Armelagos 2003). By adopting a biocultural perspective (Baker and Agarwal 2017), bioarchaeology – the discipline studying the human skeletal remains of the past – promotes a contextualisation of human skeletal and dental remains (i.e. the biological data) to improve our understanding of past populations, behaviour, adaptability, health and death. The biocultural perspective considers humans as both biological and cultural beings in which cultural influences can affect the biology of the human body in observable ways; moreover, the biocultural approach evaluates how culture interacts with the environment (Stinson *et al.* 2012). As pointed out by Agarwal and Glencross (2011: 1), 'the duality of the skeleton as both a biological and cultural entity has formed the basis of bioarchaeological theoretical inquiry'.

Bioarchaeology is a vibrant and interdisciplinary field of study, which encompasses multiple disciplines such as archaeology, human osteology and social theory, aimed at placing past communities in their biological, cultural and environmental context. The methodological approach of the bioarchaeology research field relies on the emphasis given to the integrative analysis of human remains within their context, including the archaeological, socio-cultural, and political aspects as well as the environmental contingency in which the ancient populations lived (Sheridan 2017). The consistency of bioarchaeology lies in its multi-scalar approaches, which embrace the use of advanced techniques such as molecular and chemical analysis, alongside ecological, ethnographic, and historical perspectives (Larsen 2018). Bioarchaeology investigates issues related to demography, spatial organisation, epidemiological transitions, human ecology, health conditions, socio-political changes, economic strategies, variation in resources access and social theoretical approaches to the understanding of how people experienced an array of circumstances over the course of their lives. The various components of the discipline can thus be summarised in the 'bioarchaeological model' illustrated in Figure 1, in which material culture is associated with skeletal remains to create a timeline for the ecology of health.

The model underscores how bioarchaeology must incorporate the analysis of skeletal remains within an archaeological, socio-economic and historical framework. In fact, the core of bioarchaeological research is the relationship between bone biology and the human behaviour, with special attention to

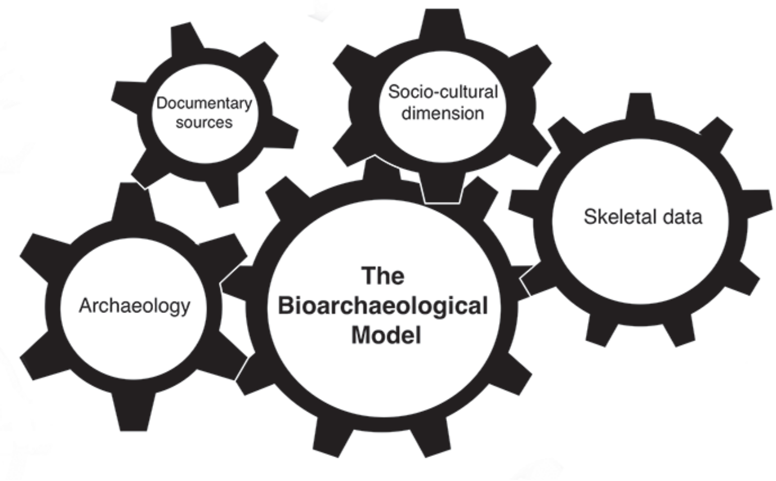

Figure 1. The Bioarchaeological model combines information from the biological and social sciences for a more holistic reconstruction of the past (Source: Author).

the effects of environmental influences on health and living conditions (Larsen 2015). The duality of osteoarchaeological remains as both biological and cultural entities represents the basis of social theory (Armelagos 2003; Buikstra and Beck 2006), the objective of which is to provide a reconstruction of the social identity based on sex, age or health in the past (Knudson and Stojanowski 2008; Sofaer 2006). The inclusion of social theory within the bioarchaeological model aims to overcome the traditional binary perception of biological data and material artefacts and to consider human remains as a biological and cultural phenomenon (Sofaer 2006).

Archaeological human skeletal collections provide a unique resource to understand the relationships between human culture and biology, including the study of disease dynamics across space and time. In this context, a focal point of bioarchaeological research is the investigation of stress indicators or markers in human skeletal remains in relation to adult health. As such, 'stress' is a fundamental concept which must be clarified for the purposes of this study. The word 'stress' is used in physics to refer to the interaction between a force and the resistance to oppose that force. Hans Selye, a pioneering Hungarian-Canadian endocrinologist known as the father of 'stress research' first included this term in the medical lexicon. He conducted several scientific experiments, postulating the importance of neuroendocrine mechanisms in the development of stress response. According to the early definition given by Selye, stress is 'the non-specific neuroendocrine response of the body' (Selye 1936; 1950a; 1950b), in which the stress response is induced independently of the nature of the stimuli. Later, he preferred to eliminate the word 'neuroendocrine' as he realised that almost every other vital system (e.g. cardiovascular, renal and pulmonary) was involved beyond the neuroendocrine system.

During his experiments on rats (1936), Selye showed that a diverse range of stressors including colds, injuries and the administration of chemical substances led to stereotypical physiological and hormonal processes that he called 'general adaptation syndrome' (GAS syndrome) and that he defined as the 'ability of living organisms to adapt themselves to changes in their surroundings' (1950a: 1383). This syndrome develops in three stages, i.e. alarm reaction, stage of resistance and stage of exhaustion (Selye 1950a; 1950b); stress response concerns the physiological mechanisms whose manifestations are primary hormonal responses produced by the adrenal cortex and the secretion of the adrenocorticotrophic hormone (ACTH) (for a review of Selye's works, see Szabo *et al.* 2012). In his researches, Selye neglected the study of specific disease signs and symptoms, choosing to focus purely on the patient's universal reactions to maladies, thus emphasising non-specificity as the main characteristic of stressors, i.e. various agents/factors causing stress as response (Selye 1950a; 1956; 1976).

Over time, other different definitions of stress were proposed by Selye in his works, identifying it as 'not a specific reaction' (1956: 54) or the 'nonspecific response of the body to any demand' (1976: 74). Although Selye dedicated his entire scientific career to providing proof of the importance of neuroendocrine mechanisms through the publication of papers and books, the major dilemma was the incapacity to give a univocal definition of stress. Non-specificity of Selye's definition of stress was subjected to criticism; therefore, the concepts of stress and stress response have varied in form and context throughout the decades with the contribution of other researchers who have attempted to narrow these notions and to make their definition less nuanced. In the 1970s, medical researchers (e.g. Mason 1971; Lazarus 1976; Cox 1978) argued against the GAS proposed by Selye, as it seemed to describe the response of an individual to stress in a too superficial manner. According to these authors, the psychological component and its impact were not taken into account in the physiological stress mechanism of an individual.

It is well known that the word 'stress' has become highly ambiguous and colloquial over the years and alternative terms have been proposed by McEwen (1998) and McEwen and Wingfield (2003) in an attempt to reinterpret Selye's concept of stress. However, new definitions such as 'allostasis' and 'allostatic load' (i.e. the adaptive processes that maintain homeostasis through change) have been criticised by Dallman (2003), who still preferred the widely used terms 'stressor' (stimuli which evoke physiological stress) and 'stress responses' (changes in the brain and body that occur as a consequence of persistent stress) (p. 18). Further efforts in the definition of stress have been made by Romero *et al.* (2009), even though they admit that it is a highly complex concept, with many different meanings pooled together, and even resulting in vulnerability to a charge of circularity (Romero *et al.* 2009). The lack of an unequivocal definition of the concept of stress is somehow connected to the fact that the term 'stress' incorporates three meanings: a) stimuli that cause a stress reaction; b) the physiological response to stimuli; and c) the pathological consequence resulting from an overstimulation of the natural physiological response.

Romero *et al.* (2009) developed a new model, defined as the 'Reactive Scope Model', in which the concepts of homeostasis, allostasis, and stress are integrated to understand different reactions to stressors (Figure 2).

This model presumes that hormonal, behavioural, and physiological mediators exist at four levels of activity. The first two levels form the normal reactive scope of

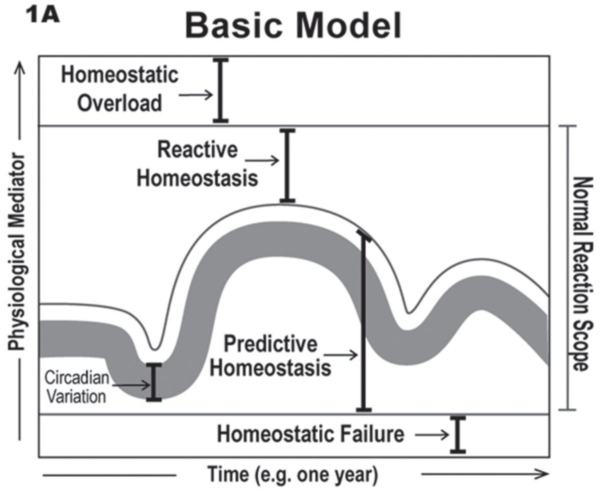

Figure 2. The Reactive Scope Model proposed by Romero *et al.* 2009 (reproduced with permission 4950621142886, Elsevier)

the organism. In particular, 'predictive homeostasis' is concerned with normal daily and yearly variations of the mediators (Romero *et al.* 2009), while the second level, 'reactive homeostasis', refers to the necessary reaction to abnormal environmental stressors (Romero *et al.* 2009). The other two levels of activity are categorised as pathological. 'Homeostatic overload' has been defined as the range of allostatic responses in which symptoms of chronic stress manifest with a high intensity or prolonged duration (Romero *et al.* 2009), while 'homeostatic failure' occurs when a response is insufficient (Romero *et al.* 2009). Yet, as stated by Romero *et al.* (2009), the normal Reactive Scope model can vary 'between individuals and within a single individual in response to certain stimuli' (p. 380); therefore, when considering responses to stress in human skeletal remains, such concepts can be beneficial in gaining a deeper understanding of the osteological response.

In bioarchaeology it is necessary to consider stress response, the way in which it is determined and its severity, as well as the physiological changes that might occur in relation to differing levels of stress response. It is clear that individuals are characterised by different levels of susceptibility or frailty and these might change over their lifespan and might be influenced by different factors (e.g. environmental and nutritional). Indeed, understanding stressors involved in human-environment interactions is crucial to interpret health in past societies. Stress as a physiological disruption occurring from environmental circumstances that interfere with homeostasis can be considered the product of three main components: a) environmental constraints; b) cultural buffering system; c) host resistance. Stress models adapted for studies in bioarchaeology were first conceived by Goodman *et al.* (1984), revised by Goodman and Armelagos (1989) (Figure 3), and ultimately readapted by Klaus (2012) The common denominator of these models is that they aim to interpret human interaction with external stressors at an individual and a population level, with a focus on how this interaction was managed through cultural buffering systems. The ultimate goal is to assess global health outcomes.

The linkage between stress and health is hard to define. 'Health' is another concept the World Health Organization (WHO) defines as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO 1948).

As well expressed by Reitsema and McIlvaine (2014), although 'health' as a concept exists, the significance of 'healthy' is ambiguous, even more when this concept is considered in relation to past communities. Moreover, it is well-known that 'stress' and 'health' are not interchangeable terms in bioarchaeology (McIlvaine and Reitsema 2013). In an attempt to reconcile 'stress' and 'health', Reitsema and McIlvaine (2014) thus suggest considering that 'physiological changes in the body as a result of stress are unhealthy' (p. 181). In these terms, 'stress' appears to be a useful proxy to assess health conditions in skeletal assemblages; by accepting this view, what bioarchaeologists can gain are potential insights into the synergistic connections between physiological stress response and etiological frameworks, whether biological, nutritional, cultural (i.e. buffering systems) and psychological (Reitsema and McIlvaine 2014). However, as expressed by Temple and Goodman (2014), the association of the health concept with skeletal remains is problematic and should be reconsidered, since the term 'health' involves factors that cannot be read in the skeleton (see WHO definition). For this reason, bioarchaeological studies should consider that skeletal indicators of stress 'are not measuring health outcomes, but instead, evaluating stress[1] within a community' (p. 189) and, more specifically, that 'skeletal indicators of stress and disease represent disruptions to physiological homeostasis at particular points of development, but do not necessarily act as a cumulative health index' (p. 190). Further clarification on how stress should be considered in bioarchaeological studies has been outlined by Klaus (2014): 'the goal is to elucidate the interplay therein (i.e. in bioarchaeology), where stress and behavior interact with underlying biology, diet, ecology, and socio-political structures to disrupt biological functioning. Also, what probably best

[1] Throughout this current work the concept of 'stress' has been considered as a physiological disruption resulting in tangible traces in bones and in teeth, and resulting from cultural, environmental and nutritional constraints. Although not quantifiable in skeletal remains, even the psycho-social variables require consideration in the final contextualisation of stress indicators.

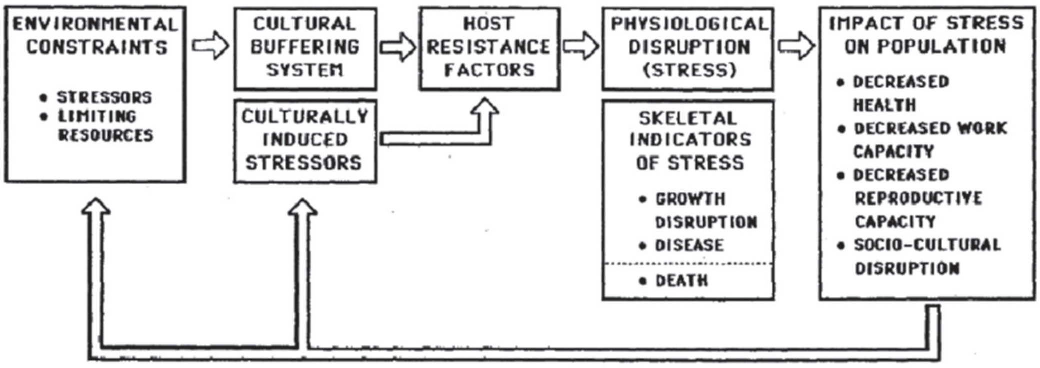

Figure 3. Stress model used for the evaluation of stress in skeletal populations (from Goodman and Armelagos 1989, reproduced with permission 4950640590243, Taylor and Francis)

describes stress-related phenomena is not homeostasis. More complete and dynamic understandings emerge from the concepts of allostasis [...]' (p. 295).

1.2 Bioarchaeological literature on stress markers and analysis of transition periods in the Italian agenda

Following well-developed research agendas on stress in other disciplines, most notably psychology and physiology as reported above, the 1980s have witnessed an increase in research on stress in physical anthropology. One of the most ground-breaking works was the volume *Paleopathology at the origins of Agriculture*, edited by Cohen and Armelagos (1984), which aimed to understand scientifically the role of stress in ancient populations by considering biological anthropology and cultural components as a whole. Osteological collections coming from various geographical areas were collected into this first comprehensive volume, which addresses how adoption and the intensification of agriculture impacted populations lifestyle and health in North America, Eastern Asia and the Levant. Four aspects were primarily dealt with: adoption of a population perspective, intrapopulation comparison over time, perception of cultural factors (social organisation, economy, ideology) able to influence the pathologic process and assessment of multiple stress markers. After this comprehensive synthesis, a large body of literature concerning the effects of socio-cultural factors on Pre-Columbian skeletal collections has been generated in the North-American bioarchaeological tradition (e.g. Goodman *et al.* 1984; Goodman *et al.* 1988; Buikstra and Milner 1989; Armelagos 1990; Milner 1992).

The project 'The Backbone of History: health and nutrition in the Western Hemisphere' (Steckel and Rose 2002a) brings together a database of 12,520 individuals, mostly Native Americans, alongside small subsamples of Euro-Americans and African Americans who lived between 4000 BC and the early 1900s. The aim of this large dataset is to study long-term trends in health by considering eight stress indicators: stature, oral pathologies, osteoarthritis, enamel hypoplasia, *cribra orbitalia*, porotic hyperostosis, trauma lesions and periosteal reactions. The distribution of stress markers is correlated with environmental factors such as settlement, topography, and substance economy, thus reflecting a relationship between ecology and past communities as conceptualised in medical anthropology of living populations (McElroy and Townsend 1996; 2009; 2015). The framework in which medical anthropology operates is a multidisciplinary field which integrates integration anthropology, ecology, and medicine to interpret how environmental and cultural contexts influence human health, both in small and more complex societies. The approach of medical ecology is also useful to understand the dynamics of the past, as the ancestors experienced comparative issues in terms of food strategies and population growth, alongside challenging environments (McElroy and Townsend 2009; 2015).

As the scope of this Introduction section is to provide a general overview of the major contributions within the field of stress research in bioarchaeology, it is important to note that the European tradition displays a paradigm shift on the specific topic of stress markers and health conditions by using a multi-temporal sequence. In northern Europe,[2] the British academic tradition reached a milestone with the work of McWhirr *et al.* (1982), whose investigations were focused on the single Romano-British site of Cirencester in Gloucestershire, and with that of Molleson (1993) dedicated to the Romano-British archaeological site of Poundbury Camp (3rd-5th centuries AD) in Dorset.

[2] A subregion geoscheme for Europe was created by the United Nations (UN), which defined northern Europe as composed of Scandinavia, the Baltic countries, the UK, Ireland, northern Germany, northern Belarus, and northwest Russia. Southern Europe was defined as consisting of the Iberian Peninsula, Italy, and the Balkan Peninsula (from United Nations 1999).

In contrast, Roberts and Cox (2003) presented data from a total of 34,797 skeletons belonging to 311 archaeological sites, providing a history of health conditions in Britain on a large temporal scale, from the late Upper Palaeolithic to the post-Medieval periods. More recently, studies concerning British transition periods in the Dorset region were conducted by Redfern (2008), who investigated the effects of cultural changes on demography, stature, oral health and infectious diseases during the Iron age and Roman times (4th BC-4th centuries AD), even by comparing Roman rural and urban settlements in Dorset between the 1st and 5th centuries AD (Redfern *et al.* 2015).

The analyses of transitional periods within southern European[2] bioarchaeology are scarce; only a few studies can be found, which address the consequences of a socio-cultural transition on health. An evaluation of stress markers (e.g. *cribra orbitalia*, linear enamel hypoplasia, nonspecific periostitis and trauma) during the transitional period between Late Antiquity (3rd-5th centuries AD) and the early Medieval period (6th-10th centuries AD) in Croatia can be traced in the report by Šlaus (2008), where the author underlines a general deterioration of living conditions during the Medieval period.

Looking specifically at the Italian context,[3] reports based on stress markers using a diachronic approach can be detected in Cucina (2002), who explored the frequency of a single stress marker (i.e. linear enamel hypoplasia) in Neolithic, Copper Age, and Early Bronze Age skeletal samples from the Trentino region in northern Italy. In historical times, the analysis of dento-alveolar pathologies in two Roman Imperial age necropolises (1st-3rd centuries AD), *Lucus Feroniae* and Isola Sacra, and an early Medieval cemetery, La Selvicciola (7th century AD) in central Italy, showed a decline in living conditions during the transition to the Medieval period, with an increase of caries, alveolar abscesses, antemortem tooth loss and enamel hypoplasia (Manzi *et al.* 1999). However, through the analysis of the same osteological material, a clear discontinuity in living conditions between the Roman Imperial Age and the Early Middle Ages was also documented by Salvadei *et al.* (2001), who considered other stress indicators such as orbital and cranial pitting.

In contrast, research conducted in southern Italy (Belcastro *et al.* 2007) suggests a different scenario in which the frequency of dental and skeletal indicators (i.e. dento-alveolar diseases, linear enamel hypoplasia, *cribra orbitalia*, and periosteal reaction) do not reflect a true discontinuity between the Roman Imperial Age and the Early Middle Ages, as seen in two skeletal samples from the necropolises of Quadrella (1st-4th centuries AD) and Vicenne-Campochiaro (7th century AD) in the Molise region. Bioarchaeological inferences about lifestyles over time were addressed in Vercellotti *et al.* (2014), where the authors explored adult stature variability and other skeletal and dental stress indicators (*cribra orbitalia*, porotic hyperostosis, linear enamel hypoplasia) in two Medieval osteological collections from northern Italy and Poland, suggesting that 'a population's tall stature may be more indicative of high selective pressures than of positive life conditions' (p. 229).

In an attempt to extend the medical approach used in the Western Hemisphere Project (Steckel and Rose 2002b), a macro-bioarchaeological dataset has been recently built and labelled 'The Backbone of Europe: Health, Diet, Work and Violence over Two Millennia' (Steckel *et al.* 2019a). This work focuses on health conditions in 15,119 skeletons from 103 European contexts, within a chronological interval spanning from the Classical Antiquity (AD 300) to the Industrial period (AD 1900). The same methodological approach (considering seven parameters including stature, oral pathologies, osteoarthritis, enamel hypoplasia, *cribra orbitalia* and porotic hyperostosis, trauma lesions, and periosteal reactions) has been adopted within this new project, aimed at evaluating how different environmental factors, climatic changes and socio-political and economic systems occurring after the fall of the Roman Empire have interacted with European communities during the entire Medieval period and until the Industrialisation process. The osteological data integrated in 'The Backbone of Europe' were extrapolated from many countries in Europe, including Austria, Cyprus, England, France, Germany, Greece, Hungary, Lithuania, the Netherlands, Poland, Portugal, Romania, Sweden, Switzerland, and Ukraine, some of which contributed much more in terms of numbers of archaeological sites and skeletal material available (Figure 4).

As argued in the Introduction section by Steckel *et al.* (2019b: 1-10), scarcity or lack of data from countries of the Mediterranean area, such as Spain (only two sites considered) and Italy, raises the question as to whether this dearth of information might potentially influence the overall health status in Europe. In this regard, Italy has been mentioned only in relation to a single stress indicator (periosteal reaction), referring to the Roman Imperial urban necropolis discovered in the city of Urbino (Paine *et al.* 2009; Marques *et al.* 2019).

An historical transition such as that from the Roman Empire to the Middle Ages represents one of the most challenging periods for discussing 'stress' in Italian and, more broadly, European archaeology. Indeed, the geographical position of the Italian peninsula at the

[3] For a geographical division of the Italian peninsula, see Nomenclature of Territorial Units for Statistics (NUTS), Eurostat.

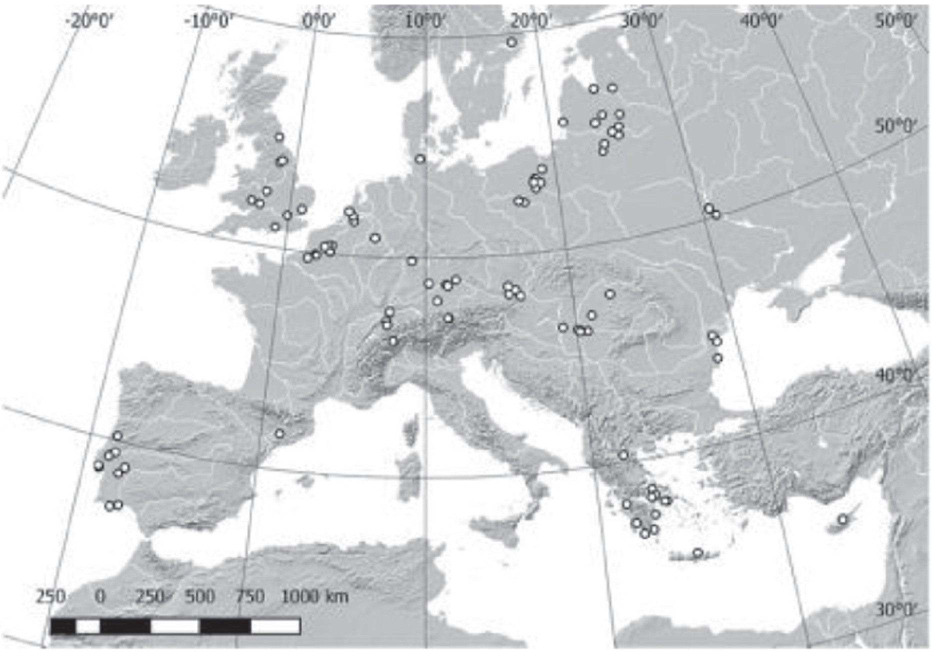

Figure 4. Map of European countries from which the osteological data included in 'The Backbone of Europe' were extracted (from Steckel *et al.* 2019b, p. 3, reproduced with permission PLSclear 44213, Cambridge University Press).

core of the Western Roman Empire, rather than in its periphery, may reveal unprecedented osteological evidence for diversification rather than a general collapse or stagnation of living conditions.

1.3 Research questions

As human skeletal remains provide a unique window in assessing life conditions and stress loads among past communities, the purpose of this study is to consider, for the first time, skeletal assemblages coming from urban and rural contexts in Tuscany (central Italy) to evaluate how past populations faced the transitional period between Late Antiquity (3rd-5th centuries AD) and the Middle Ages (mid 6th-mid 13th centuries AD).

The transition from the Classical to the post-Classical age is characterised by socio-political and economic disruptions in Europe, undoubtedly leaving its mark on the historical consciousness of populations living in this part of the world. Nevertheless, the degree to which all strata of society were impacted by this turbulent period is still under debate, with the negative view of the so called 'Dark Ages', often being homogeneously seen as an impoverished and stagnant phase, particularly for communities in the Mediterranean basin. Considering its prominent role at the core of the Western Roman Empire and, consequently, its greater vulnerability to the major historical shifts of the 1st millennium AD, such questions are extremely important for central Italy.

To accomplish this, four stress indicators including adult stature, periosteal reaction, *cribra orbitalia* and *cribra cranii*, and linear enamel hypoplasia, were compared in 390 skeletons: 169 from the Late Antiquity urban necropolis of Via Marche (Pisa) and 221 from two rural sites, namely *vicus Wallari/borgo San Genesio* (San Miniato, Pisa) and Pieve di Pava (Siena), both dating to the Middle Ages. A palaeodiet analysis was also carried out in selected samples by using different elements of the skeleton in a single individual to gain additional information about dietary changes through a person's lifetime.

This research aims to verify whether or not there was any discontinuity in Tuscany from the point of view of stress load and dietary patterns, by applying a biosocial perspective in archaeology that focuses on the dynamic interplay between humans and their socio-cultural environment in order to increase the understanding of adaptive plasticity and constraints. Evidence of 'health' and cultural buffering systems adopted were interpreted in the light of socio-economic and environmental contexts, with special attention as to how they changed during Late Antiquity and the Middle Ages in urban and rural contexts.

It is well known that the collapse of the Western Roman Empire produced environmental stressors, such as new spatial re-assessment, modification in human-landscape interaction, new economic strategies, as well as a diversity in food resources and social synergies with

Germanic populations, which were marked by different cultural behaviours. Exploring the relative importance of these different external anthropogenic and climate factors, as well as of landscape reorganisation and the distribution of a variety of food among Italian communities in Late Antiquity and the Middle Ages, remains a fundamental, but still under-studied area of bioarchaeological research. Specifically, three research questions should be addressed:

- Can a difference in demographic structure be traced between the two historical periods?
- How did environmental and socio-cultural changes influence the lifestyles of Tuscan communities?
- Does isotope analysis hint at distinct palaeodietary scenarios between Late Antiquity and the Middle Ages?

The use of a population-scale analysis helps understand urban and rural differences within a multi-temporal scale (i.e. the transition period between Late Antiquity and the Middle Ages) and allows us to evaluate how ecological factors affected living conditions as well as the socio-cultural and economic perturbations that occurred after the fall of the Roman Empire. In an attempt to offer new insights into the 'health' conditions of central Italy for the two historical periods considered, and to fill the informative gap as outlined in the Introduction section of 'The Backbone of Europe' (Steckel *et al.* 2019b), three different lines of research are addressed:

- Analysis of the transition period and not merely of a single temporal *fenestra*;
- Assessment of multiple skeletal and dental stress indicators at population level;
- Inclusion of isotope analysis considering both tooth and bone tissues as different elements from the same individual, offering information on the dietary changes through a person's lifetime.

Therefore, the main goal of this research is to produce a regional study by examining stress indicators in ancient communities over time at a population level of analysis. Different components that characterise both urban and rural contexts in Tuscany will be taken into account. This approach should make it possible to achieve a better understanding of stress load and stressor exposure of Tuscan communities in relation to political changes, economic models of subsistence, and socio-cultural and bioarchaeological aspects.

Osteological data from Tuscany seem to suggest a more complex transition between Late Antiquity and the long Medieval period, as proven by evidence of heterogeneity in which a great many variables may have played a role and should be taken into account. Although the population-level approach has also permitted comparison of other Italian and European health patterns, caution should be used, considering the substantial disparities in climate, environment, society, technology, economy, and dietary habits between the different geographical areas inhabited by past human groups.

The direct testing of hypotheses concerning the ways in which Italian populations would be affected by social, political and economic changes during the passage from Late Antiquity to the Middle Ages has been hampered by scant research on osteological and nutritional data in a diachronic perspective. This is particularly controversial in a geographical context such as Italy, likely to have been mostly influenced by a shift from being the core of a pan-European empire to a reality of fragmented and isolated political entities in the post-Classical age. Therefore, osteological and stable isotope data from ancient Tuscany allow us to explore the effects of these changes on human health and nutrition in Italy, providing new keys to understanding whether the collapse of the Western Roman Empire actually led to devastating outcomes with the so called 'Dark Ages', or resulted in diversified economic and agricultural opportunities.

In this sense, a comparison with literature has been addressed with care in this work, so as to avoid a typological approach on the basis of which past populations are included in 'health categories' (Temple and Goodman 2014).