

# History of Medicine as a bridge between Paleopathology and the Medical Humanities. New Technologies Applied to Bioarchaeology: reconstructing Lifestyles in Ancient Rome

Silvia Iorio<sup>1</sup>, Paola Catalano<sup>2</sup>, Valentina Giuffra<sup>3</sup>, Flavio De Angelis<sup>4</sup>, Maria Cristina Martinez-Labarga<sup>4</sup>, Riccardo Santangeli Valenzani<sup>5</sup>, Giulia Facchin<sup>5</sup>, Marco Cilione<sup>6</sup>, Valentina Gazzaniga<sup>1\*</sup>

<sup>1</sup> Sapienza University of Rome, Department of medico-surgical Sciences and Biotechnologies, Italy

<sup>2</sup> Soprintendenza Speciale Archeologia, Belle Arti e Paesaggio di Roma (already), Italy

<sup>3</sup> University of Pisa, Italy

<sup>4</sup> University of Tor Vergata Center of Molecular Anthropology for Ancient Dna, Department of Biology, Italy

<sup>5</sup> University of Roma Tre, Italy

<sup>6</sup> University of Modena e Reggio, Italy

## Abstract

The research project *Diseases, health and lifestyles in Rome: from the Empire to the Early Middle Age* (PRIN 2015), covered a significant area of research, ranging from the historical and historico-medical content that emerged during the multi-disciplinary investigation on the subject, to the intersection between different methods and approaches and the full enhancement of truly primary sources that included human skeletal remains, food residues, housing situations and burial contexts. From this perspective, the interest in the so-called “material culture” has taken on a more important meaning than the simple response to a conceptual and ideological historiography. Since the 1980s, there has been a sort of limitation regarding a more objective reconstruction of Antiquity. In general, written and iconographic sources convey information that is more or less intentionally mediated by the cultural and anthropological coordinates that produced it, requiring the historian to make a philological exegesis effort that even in the case of manuscripts and epigraphs needs to dialogue with tools of support and writing. On the other hand, the importance of molecular data would be partial and misleading if it were to be based on a more traditional documentary framework. Therefore, the history of medicine, always accustomed to operating in an area dedicated to a mixing of different areas of expertise and study, has once again proved capable of creating a dialogue among areas of study that are seemingly distant from one another. However, these areas of study are complementary, leading to a reliable historical reconstruction. In fact, the choice to focus the investigation on the human body has also inevitably highlighted the οἶκος in which it finds itself. This is part of a dynamic natural and social system, as was perfectly clear to the legislators of the late-Republican period and to doctors of imperial age, including Galen, who were well aware of the connection among health, productive and manufacturing activities, urban planning, pollution and food. Therefore, the anthropological, paleo-pathological and molecular investigation on skeletal remains, in dialogue with the historical-medical, literary and iconographic sources, has become the opportunity for a historical reconstruction. This reconstruction is all the more interesting as it encompasses a time frame that contains the transition from the Late Antiquity to the beginning of the Middle Ages, allowing for the identification of a series of indicators on continuity and discontinuity.

\* Corresponding author. E-mail: [valentina.gazzaniga@uniroma1.it](mailto:valentina.gazzaniga@uniroma1.it)

---

**Keywords**

multi-disciplinary investigation; history of medicine; bioarchaeology; lifestyles in Rome; Early Middle Age.

**Introduction**

Our research focuses not only on the history of the concepts of lifestyle, health and disease and medical theories, but we also look at material history, made up of unwritten documents, architectural constructions, objects, artefacts and bones. For a long period of time, the historiography of medicine has left the material findings confined to a liminal dimension, in some way an accessory to a more intellectual sphere – that which was represented by the study and understanding of the written text. Certainly, historical research based only on unwritten testimonies will never be able to fully reconstruct the complex panorama of lifestyles and medicine in antiquity. Equally true, however, is the fact that the traditional historiography of medicine, limited to considering the “noble” voices written on the concepts of health and disease, on therapy and on the control of lifestyles, has ended up neglecting some fundamental aspects for the same internal understanding of texts. Moreover, the analysis of ancient texts does not ignore the fact that the written sources are also “material”. Consequently, the examination of the epigraphic literature, together with the investigation of the funerary steles (halfway between texts and findings) allows, over a long period of time, to focus the Western medical tradition also through reflection on the history of certain supports (Cilione, 2016).

A good example of how a “collateral” and integrated approach to ancient scientific and medical knowledge is useful for the reconstruction of disease and pathocenosis in ancient times was already available for some time thanks to Mirko D. Grmek (Grmek, 1969).

Today, prospects for investigation have been enriched and enhanced. Data from material history, specifically those related to the studies of physical anthropology, paleopathology and molecular anthropology, have increased in number. Moreover, this type of data is more structured than in the past. Above all, they can be reinterpreted through the use of cutting-edge technology. The aim of this project was to increase, promote and spread the knowledge and protection of the culture of humanity, history and biology of a representative portion of the population in the European tradition.

The importance of the study lies in the intention of offering the possibility of presenting the results of an integrated approach applied to the reconstructive practice of the daily living conditions of the population of ancient, late ancient and early medieval Rome. In this interaction, the anthropological and molecular investigation and the study of the excavation come together in order to allow for a cross-referencing of the paleo-pathological and paleo-nutritional data with the ancient medical sources (clinical pictures, diseases, pharmacological preparations) in order to reconstruct around the finds a series of case studies that identify the physiognomy of an individual in Rome on the basis of biological specificity and lifestyle, as well as nutritional and socio-cultural habits.

Through the collaboration between Sapienza University of Rome and the Anthropology Service of the Special Superintendence for the Colosseum – the Roman

National Museum and the Archaeological Area of Rome, the University of Tor Vergata, the University of Roma Tre and the University of Pisa, this project aimed at reconstructing the lifestyle during the Empire and the Middle Ages in Rome through a cross-examination of material sources based on medical and literary texts.

Through a diachronic analysis, we focused on the understanding of the biological and social landscape of the population of ancient Rome, late ancient and early medieval Rome. This approach was carried out in order to also correlate – in comparative terms – the current re-emergence of related infectious, nutritional and socio-environmental risks to health determinants. Furthermore, these data were enhanced when the epidemiological factors concerning the displacement of populations were compared – a phenomenon that today as in antiquity has affected the European territory. By comparing the literary, epigraphic and archaeological data with the paleo-demographic, paleo-pathological, paleogenetic, paleoparasitological, paleo-nutritional data and from ergonomic and morphometric analyses on the skeletal remains of numerous Roman individuals, the study aimed to contribute to the reconstruction of lifestyles, working and living conditions, as well as socio-environmental conditions. Consequently, the study attempted to reconstruct the Roman pathocenosis from the Empire to the early Middle Ages. The comparative study on molecular data provided by bioarchaeological finds, excavation materials, as well as historical-medical and literary sources is also aimed at obtaining information on the evolution and genetic variability of pathogens. This study also focuses on clarifying the role of encounters between populations, lifestyles and socio-environmental conditions on the etiopathogenesis of some diseases (i.e. infectious pathologies vs. trade and transport routes; infectious pathologies vs. frequency of spas; infectious pathologies vs. migration routes and flow; nutritional deficiency pathologies; pathologies due to poor food storage; pathologies and workloads; social care of sick individuals, etc). The relevance of this project was also determined by the large number of biological and archaeological remains available. This allowed for a singular and rather important statistical elaboration in the study of the populations of ancient Rome, considering that other European archaeological sites do not contain this wealth, despite being intensively studied.

Ancient human remains represent a biological archive of information that is fundamental for the study of humankind. These remains make it possible to obtain data on habits, quality of life, state of health and disease of the populations of the past, as well as on hereditary and evolutionary aspects in the strict sense (Ferrari 2010). In addition to the scientific results obtained from medical examinations, we should also underline the importance of ancient human remains and archaeological finds as a cultural heritage to be preserved, protected and valued. These cultural assets are the subject of multi-disciplinary study in which archaeology, history, biology, natural sciences and medical sciences collaborate to address very complex problems such as variability, microevolution, environmental adaptation mechanisms, and, in general, pathocenosis (Gourevitch, 2011).

Today, the progress of scientific knowledge allows for achieving a vast archive of anthropological data that allow us to accurately describe many aspects of the biology of the past populations and the environment where they lived, also providing information complementing the culturally-pertinent aspects. The molecular analyses to establish the genetic information and the dietary pattern, and the paleo-pathological investigations carried out on these assets not only increase the biological and histori-

cal archive, but also provide important information for the space-time location of the single individual. Isotopic analyses carried out on bone tissues allow for obtaining concrete elements for dating and, due to the recent bio-technological developments, for the identification of the geographical area in which the individuals lived, in order to implement the current information on preserved human artefacts. The investigations of paleo-immunology and molecular paleo-microbiology carried out on skeletal findings allow us to formulate a retrospective diagnosis of specific diseases, as well as to obtain epidemiological data to be used in the reconstruction of the history of the same diseases. The most recent developments in this area of study concern the application of immunology and molecular biology on ancient human remains. Paleo-immunology uses modern immunochromatographic tests and serological analyses (WB) in order reach a retrospective diagnosis of ancient pathogens in human remains. Thanks to this technique, important results have also been obtained for the study of diseases that were widespread in the past in Italy, such as the plague and malaria (Bianucci et al., 2015; Cesana et al., 2017).

The exploration of aspects that have long been neglected by traditional historiography sheds a new light on life in Rome between the imperial age and the High Middle Ages and imposes a rewriting of events and socio-political phenomena that consider nosological frameworks, dietetics, lifestyles and migration flows.

In the light of this multidisciplinary approach to the theme of research and the spirit of scientific collaboration that has animated the scholars involved in the project, the results of the work of the individual units can easily be disrupted and reorganized in thematic areas.

## **Nosological framework**

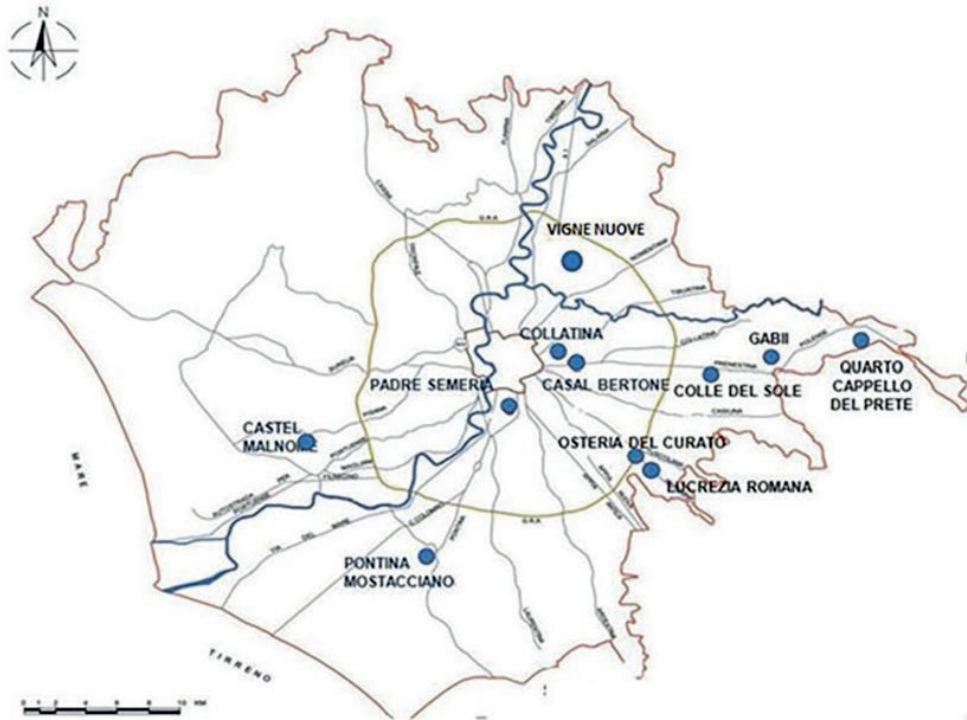
The paleopathological study focused its work on the bioarchaeological and paleopathological studies of skeletal remains recovered in some Roman necropolises from the Imperial Age to the Early Medieval Age with the aim to obtain information about the social, demographic, and health patterns of ancient Rome.

Examination of hundreds of individuals from Roman Imperial Age necropolises allowed the identification of pathological conditions that resulted in bone alterations.

The most relevant diseases observed regards neoplasms. Nowadays cancer represents the second most common cause of death (Boyle, Levin, 2008) in developed countries. In particular, malignant tumors are considered the result of carcinogenic environmental factors in industrialised societies. (Siegel, 2020)

Tumours have been documented since the most ancient times, but the paleopathological evidence of these diseases among past populations are scarce. The main reason for the lower incidence of cancer in the past is represented by the lower life expectancy, considering that these diseases generally occur in the elderly. Furthermore, in paleopathology only cancer types affecting the bones can be detected, whereas malignancies often led to death before involving the skeletal apparatus. Finally, the poor preservation of ancient bones, especially those affected by destructive disorders, may prevent the observation of some evidence.

An important and rare case of metastatic carcinoma was brought to light from the Imperial Age necropolis of Casal Bertone, located near some residential structures



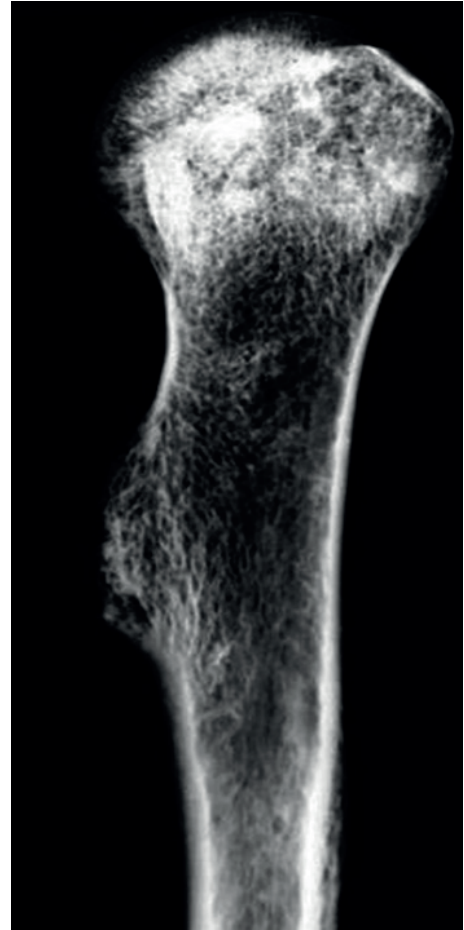
**Figure 1.** Location of the examined graveyards.

and a large place identified as a fullery (*fullonica*). The skeleton of an adult man displayed severe and widespread bone alteration consisting in mixed osteoclastic and osteoblastic lesions mainly involving the axial bones. The morphology of the lesions, which are both destructive and proliferative, and their anatomical distribution suggested a diagnosis of metastatic carcinoma arising from a soft-tissue primary cancer. The age and sex of the individual, together with the radiographic and histological aspect, permitted to hypothesize a prostate cancer as the site of origin. The archaeological evidence suggests that this individual probably worked in the *fullonica*. These workers were in daily contact with chemical agents such as soda, urine and sulphurous vapours used to scrub, wring and whiten the cloth. However, there is no evidence in the current clinical literature that these chemical substances can be related with the occurrence of malignancies. Therefore, it is not possible to verify the impact of environmental factors on the onset of tumour in this individual. The good state of preservation of the skeleton and the advanced stage of the prostate cancer represented a relevant opportunity to observe in dry bones the natural course of the disease in absence of treatment. (Minozzi et al., 2018).

Furthermore, two cases of benign neoplasm were found in skeletal remains from the Imperial Age necropolis of Collatina. The skull of two adult males displayed evidence of paranasal lesions. In both cases, the detection of the new bone formations



**Figure 2.** Left humerus osteochondroma.



**Figure 3:** X-rays antero-posterior view of the proximal.

has been possible thanks to *postmortem* damage in the frontal bone. Radiological examination confirmed the presence of pediculated-based bone formations arising from the right frontal sinus, which can be interpreted as osteomata. In both cases the reduced dimensions, lower than 10 mm permitted to rule out mechanical complications and compression of the adjacent structures. The osteomata of paranasal sinuses are rarely documented in paleopathology, as they can be observed only incidentally after bone breakage or radiography (Riccomi et al., 2018).

Another case of benign tumour regards a new bone formation observed in the upper arm of an adult man from the Imperial Age necropolis of Castel Malnome. The lesion, localized in the distal portion of the left humerus, was observed by X-ray showing continuity between the cortical portion of the humerus and the neoforma-

tion. In addition, the marrow cavity of the neoformation is continuous with that of the underlying bone. These characteristics point towards a case of osteochondroma in the differential diagnosis.

Osteochondroma is one of the most common benign bone lesions; it arises in bones by endochondral ossification and the most common site of occurrence is the metaphyseal region of the long bones, like the distal femur, proximal humerus, distal tibia and fibula. The growth of the tumour stops with the end of the skeletal development (Alabdullrahman and Byerly, 2021). In the Castel Malnome skeleton, the neoplasm originated from cartilage tissue at the proximal metaphyseal plate of the humerus and during growth the tumour reached a point that also involved the diaphysis.

Every new case of neoplastic disease, both malignant and benign, is important. These cases add information on the presence of these pathologies in the past. The knowledge of past patterns of neoplastic diseases could contribute to the understanding of present trends of carcinogenesis.

Another interesting pathological case was observed in the necropolis of Casal Bertone. The skeleton of a young individual – 18-20 years in age – showed severe bone alteration affecting the right coxal bone, localized in and around the acetabulum, changing its margins and internal cavity. The lesions in the acetabulum, mostly consisting in new bone production, match those of the head and neck of the right femur that shows similar modifications. In addition, osteolytic lesions have been observed in two lumbar vertebrae resulting in a large erosion of the vertebral bodies of L3 and L4 producing cloacae and the almost complete destruction of the L4 body. This condition is accompanied by irregular new bone production with similar characteristics to those observed in the femur and pelvis.

Differential diagnosis takes some diseases that can stimulate new bone production accompanied by osteolysis, located in a few anatomical districts, into account. The location of lesions in two adjacent lumbar vertebrae and the presence of abscess cavities and fistulas in the vertebral bodies suggest that this individual was affected by tuberculosis (Pott's disease).

This infectious bacterial disease mainly involves the respiratory system, but in 3-4% of cases affects the skeleton (Buikstra, 2019).

Documented in Italy since the Neolithic, it is not surprising that it may have been present and widespread in a city with high density of population like Rome, as indeed testified by other cases from the Roman Imperial Age (Via Nomentana, *Herculaneum*) (Canci et al., 2005).

Traumas represent one of the most widespread and easily observable diseases in skeletal remains (Giuffra and Fornaciari, 2021) Hematomas, muscle tears, and bone fractures induce reparative bone processes and are well identifiable in the skeleton, providing information on the risks of work activities, interpersonal violence and socio-environmental vulnerabilities. Healing patterns can also clarify the degree of medical care and social cooperation within a community (Buikstra, 2019).

In the Imperial Age necropolis of Castel Malnome, 243 individuals were examined and over half of them showed evidence of traumas, mainly affecting males (Caldarini, Zavaroni, Benassi, 2015). Bone fractures were observed in 25% of individuals. The lower limbs were the most affected bones, followed by ribs, clavicles, and upper limbs. Among individuals with bone fractures, 19% show multiple traumatic evi-



**Figure 4.** Enamel hypoplasia in permanent teeth.

dence; although some injuries may be attributable to a single event, others occurred in different times suggesting heavy work activities and dangerous lifestyle pattern. The higher prevalence of affected males in comparison to females, and the low prevalence in subadults, combined with the framework provided by the skeletal indicators of biomechanical activity, suggest that the Castel Malnome population, mainly males, was employed in the difficult work in salt flats that were found close to the necropolis. Trauma healing outcomes suggest the application of effective medical treatments and a good level of social cooperation within this community.

Another important point developed during the project regards the analysis of dental enamel hypoplasia, an enamel defect that occurs in childhood and results from nutritional deficiencies/diseases (Hillson, 1996).

Examination of hypoplastic lesions in ancient populations provides relevant information about developmental stress-levels the Romans during the Imperial Age and can help investigating the relation between social status and health and nutritional patterns (Minozzi et al., 2020)

Enamel hypoplasia was scored in 177 individuals from the Casal Bertone and Colatina necropolises, grouped in two sub-samples on the basis of their social status, which was identified by the types of grave typologies and equipment used (i.e. mausoleums or simple tombs).

In all the parameters considered, statistically significant differences were observed. In particular, the lower classes were more affected by linear enamel hypoplasia (LEH) than upper classes both in term of frequencies of affected teeth and of affected individuals.



Differences between males and females, or adults and non-adults were not statistically significant. The mean number of hypoplastic lesions per individual was higher in the lower class as well. It has been observed that the defects started to occur since the first year of life, with higher frequency in the lower class than in the upper class; this trend could indicate a correlation between the chronological distribution of age at onset of the stressful events and the social status.

These differences could be attributed to the more accurate parental care to the children of the upper, with better or prolonged breast-feeding. This study evidenced the relationship between LEH and social status reflecting difference subsistence patterns in the two sub-samples of the same population and indicating that the group of high social status enjoyed better health in Imperial Rome (Minozzi et al., 2020).

Regarding the Medieval period, the research was focused on the Roman necropolis recovered in Piazza Celimontana al Celio (Rome).

Anthropological and paleopathological studies were performed in 37 individuals dated back to 6<sup>th</sup>-12<sup>th</sup> centuries CE.

The reconstruction of biological profile evidenced that subadults compose 40% of the sample with high infantile mortality. Adult individuals (11 males and 10 females) are characterized by robustness and, in the same cases, marked biomechanical stress indicators. Fractures affect 50% of individuals and are mainly located on the chest and small bones of the hands and feet, likely due to dangerous living and working environments.

The study of oral pathologies shows a high rate of tooth decay, abscesses and *antemortem* tooth loss, which can be associated in part to a cariogenic diet as confirmed by biomolecular analyses. Consequently, the results suggest rather poor living and health conditions related to subsistence pattern typical of modest social classes.

In conclusion, the paleopathological evidence from ancient Rome represents a valuable contribution to compare and interpret with the data obtained from written and literary medical sources in order to expand our knowledge on the health and living conditions of this important civilization of the past.

## Dietary habits

In order to account for the nutritional significance of the Imperial-Middle Ages shift, an extensive multi-element isotopic survey was performed (De Angelis et al., 2020a; De Angelis et al., 2020b).

Collagen extraction from bone remains was carried out for every available skeleton in order to perform carbon and nitrogen stable isotope analyses (Brown et al., 1988). Carbon (C) and nitrogen (N) isotope measurements provided general information on subsistence strategies, which could differ based on sex, age, social status, and period. Selected faunal remains for several archaeological contexts were also evaluated for addressing the ecological background and establish the trophic baseline.

More than two hundred samples from the six above mentioned cemeteries (Castel Malnome, Casal Bertone Mausoleum, Casal Bertone Area Q, Casal Bertone Necropolis, Via Padre Semeria, and Quarto Cappello del Prete) represent the leading sample for Imperial Rome isotopic analysis so far. Their information has been joined to the few previously published results (De Angelis et al., 2020a, 2020b and references in it)

to obtain a broad diet reconstruction for people buried in archaeologically defined contexts in Rome (1st-3rd centuries CE), that was merged with archaeological and biological evidence for figuring out common patterns of food preferences. The dietary landscape we provide is heterogeneous, reflecting the multifaceted reality of the capital of one of the most influential empires in Antiquity.

Untangling the complexity of Roman Imperial society remains a challenge, even from a dietary point of view. However, some elements can be highlighted. One of these is the pivotal role of C3 plants, which seem to have been the staple foodstuff of the lower class. However, C4 plants also seem to have been consumed, albeit they were not as widespread and were not always used for human consumption. The environment played a critical role for Romans of lower social classes. Even though grain supplements granted by the central administration partially sustained them, the topographical location of the settlements pushed the preferential consumption of food that people could obtain from their neighbourhood to sustain active lifestyles defined by heavy labour. Nevertheless, the complexity of Roman society and trade that passed through Imperial Rome accounted for the broader range of foodstuffs available for people.

A crisis of the centralised economy marked the transition towards the Early Middle Ages (IV- V century CE), and the simultaneous closure of several trade routes shifted toward an autarchic subsistence economy (Pounds 2014). This trend was also highlighted by the carbon and nitrogen stable isotope analysis of more than one hundred skeletons (Varano et al., 2020). This resulting analysis revealed that the Medieval dietary behaviour was the direct result of the events that occurred with the collapse of the Roman Empire. The social, demographic, and economic crisis of the Roman world after the 4<sup>th</sup> century CE had a critical impact on the lifestyle.

The result was a change in the dietary pattern. A more autarchic economy was established with a significant decrease in the consumption of high protein resources. The values obtained in our survey are consistent with a diet mainly founded on the exploitation of C3 plant resources and terrestrial fauna. Grains and grain-derived products became the primary foodstuffs for disadvantaged Medieval communities that farmed a variety of grains.

Meats were the prominent component of the diet, and the data on faunal remains suggest that they were likely a food source for the people. At the same time, the results do not offer clear evidence for aquatic resource exploitation, both marine and freshwater.

However, San Pancrazio is atypical, and its high  $\delta^{15}\text{N}$  values could be related to the harnessing of riverine resources. The demographic dissection of the samples does not reveal significant differences between males and females, likewise adults and children. This evidence is striking against historical sources suggesting religious rules as a leading modifier factor for women (Mion et al., 2019). The dietary evaluation clearly detected a diachronic nutritional transition in ancient Rome, demonstrating how the complex historical period following the downfall of the Empire might have influenced the lifestyle of the Roman society. The dietary transition in the hearth of the Empire also revealed to be different from that in other areas of Europe, which could be experienced different strategies to face the collapse of the Roman Empire (Varano et al., 2020).

Furthermore, tooth enamel was studied in order to analyse the oxygen and strontium composition in people presumed not to be local based on items found in their

graves and other particular features. This evaluation could shed light on mobility patterns in ancient Rome, clarifying questions of whether the movement of ancient people was essentially unidirectional or bidirectional, occurred over long or short distances, and followed a pattern of urban to rural migration or vice versa.

More than one-hundred-fifty samples were screened. Remarkably, the relative abundance of non-local people is quite low, and people moving Rome-ward are concentrated in funerary contexts related to productive activities such as Castel Malnome and Casal Bertone, as well as in ritual area such as Quarto Cappello del Prete (De Angelis et al., 2022). The extent of mobility patterns in Medieval times is currently under debate, and we are looking for the enlargement of the sample size for providing reliable mobility models in the Middle Ages at Rome.

Selected well-preserved samples were submitted to aDNA analysis. DNA extraction was performed with improved precautions as well as a series of recently introduced methods in order to avoid the contamination (De Angelis et al., 2021; 2022 and references herein included). The genome-wide typing of human aDNA was achieved using high throughput techniques via Illumina-indexed libraries that were submitted to shotgun sequencing (Meyer and Kircher, 2010).

Genomic regions were evaluated in order to elucidate the putative phylogeographic origins of people living in Rome at the edges of the Empire. This striking task was accomplished and represent the second batch of ancient Roman genomes to date. Our results show an ancestry shift toward the eastern Mediterranean area with only a few samples suggesting a central and western European origin. The results obtained are consistent with the only previously published data (Antonio et al., 2019), even accounting for a novel north African ancestry in selected individuals (De Angelis et al., 2021; 2022).

Whenever possible, human genomic regions associated with susceptibility and/or immunity to several diseases were analysed in order to evaluate the disease-driven variation of Roman populations over time.

Some interesting information was achieved to refine the differential diagnosis based only upon osteological evaluation. Indeed, the primary evidence for diagnosing disease in the past consisted of pathological lesions in skeletal remains, so the analysis of ancient DNA allows us to look for the genetic basis of some specific phenotypes that could be linked to metabolic, genetic, or infectious diseases. Dedicated genomic studies were accomplished in cemeteries (such as Quarto Cappello del Prete e Casal Bertone De Angelis et al., 2021; 2022) characterized by the unbalanced death ratio between children and adults for the detection of the causal factors for those phenomena.

The Quarto Cappello del Prete necropolis was chosen as a paradigm for the integrated genomic approach, and the data obtained shed light on the fact that this site was home to a number of people suffering from metabolic and genetically based osteo-dysmorphic disorders. Remarkably, the genomic and isotopic approaches are consistent for suggesting people buried in that burial ground came from different geographical areas, supporting the hypothesis concerning the specific social and religious feature for this site (Musco et al., 2010).

The drastic changes between the two time periods dramatically changed Rome's demographics (Séguy 2019). Accordingly, the biological challenges of new and worsened health conditions and lifestyles arose, requiring adaptation. These turns affected

the genetic structure of the *Urbs* and, consequently, the evolution of host/pathogen interactions, resulting in the blooming of several diseases. Ancient microbial DNA was sequenced using the same procedure used for human DNA (De Angelis et al., 2022) and the analysis of specific microbes have been prioritized according to osteological and archaeological suggestions. *Mycobacterium* sp. and *Treponema* sp. were the leading microbes for which we have searched, following pathological characterisation of skeletal alterations from several individuals from the Casal Bertone area, even though the environmental microbiota represented most of the findings (De Angelis et al., 2022). This approach enhanced our understanding of the prevalence of selected diseases whose etiology could be highlighted by microbial genetic fingerprinting (imagine DNA fingerprinting)

## Lifestyles

A thorough study of the living conditions of ancient populations requires the approach of physical anthropology and paleopathology accompanied by the historical and archaeological studies. Quite certainly, this pairing is important even during the data collection phase. This approach allows, through stratigraphic analysis and typological study, for the definition of the chronology of the analysed burials and their cultural and social classification. Moreover, the study can then segment the results according to the differences of social status and follow its evolution and transformations through time.

The archaeological-historical investigation helps to clarify the framework of the analysed sample, with particular reference to nutrition, the living habitat, the likely physical activities carried out, the conditions of epidemiological risk (level of hygiene, level of interpersonal promiscuity and with pets, etc.).

The current studies on the style of life of people living during the Imperial Age precisely engaged the upper classes and their residences, with a structural architectural approach (Guidobaldi 1986; Priester 2002); only recently the attention was addressed to the social aspects of living (Allison 2004; Bowes 2010). Looking to the Late Antiquity and the early Middle Ages, conversely, the studies have been dedicated to the populace and their houses (most recently: Fronza, Santangeli Valenzani 2020 with former bibliography; see also: Galetti 2010; Santangeli Valenzani 2011), albeit here too with an interest focusing on typological and structural aspects.

Regarding the specific case of Rome, the archaeological data related to houses of the Early Medieval period (7<sup>th</sup>-11<sup>th</sup> centuries) have been treated in detail (Santangeli Valenzani 2004), with the attempt of associating the different types of buildings and the social classes of the Roman society of the time.

As part of the project, the research – focusing on Rome and the surroundings – also dealt with the building types related to the middle-low parts of the population (*insulae* for the Roman Imperial era, *domus terrineae* for the early Middle Ages) analysing a series of variables that could affect the living conditions and the state of health of the inhabitants: level of promiscuity and space availability *per capita* inside the housing unit, its health conditions (presence of isolation humidity, insolation, etc.), availability of toilets and sewage disposal systems, distance from water supply points, heating systems, presence of pets. The comparison with the

best studied cases of the upper classes residential system (*domus* with the *atrium* and similar types for the Roman era, *domus solarata* for the early Middle Ages) gave to the analysis the needed social depth, contributing to define, the articulation of the ancient societies.

Eating habits have been dealt with so far on the basis of written sources, here too with a focus on the high social classes for the Roman era, and on the peasant population for the Early Medieval era (Montanari 1979), while the archaeological approach to the topic was essentially based on the study of animal bones from excavations (De Grossi Mazzorin 2016, Salvadori 2015).

The research focussed thus on nutrition, using indicators such as the remains of meal (especially animal bones), and the cooking methods, basing the analysis on the containers used for cooking, also with the aid of molecular analysis of the incrustations preserved inside the objects. The data were provided by two ongoing excavations held in Rome by the University of Roma Tre, at the Colosseum and at the *Templum Pacis*, compared and integrated by others around Italy

Regarding the archaeo-zoological remains during the Imperial phase the pig was the most exploited animal: this species was prolific and characterized by high meat yield with cheap production costs. Between the 3<sup>rd</sup> and the 4<sup>th</sup> c. CE, the percentage of male individuals remains is high, between 73% and 88% of the entire mammal domestic population. There are rarer cases of slaughtering of old female individuals, due to their use for reproduction, and of suckling pigs, which were considered delicacy for the wealthy classes. Ovicaprines, poultry and cattle are less exploited.

This scenario starts changing during the 5<sup>th</sup> c. CE, when there is a progressive increase of the breeding of ovicaprines, which witnesses the search for different sources besides the pigs. A similar trend, together with a decrease in the slaughtering age, occurs among the cattle.

During the Middle Ages, from the 12<sup>th</sup> c. onwards, the evidence of ovicaprines progressively increases and surpasses that of pigs, to become predominant with the 13<sup>th</sup> c. The higher percentage of young individuals suggests an increase of the dairy production. At the same time also cattle grow, though with a discontinuous trend, and poultry too: the higher number of older female individuals is probably related to a larger use of eggs.

An interesting amount of remains of aquatic fauna was retrieved in the archaeological excavations too. They show that fishes in Antiquity were a sort of *status symbol*, part of the diet of wealthy people not by chance, indeed, the majority of finds, saltwater fishes and clams, comes from the sewers of the Colosseum, underneath the senatorial seats (De Grossi Mazzorin 2016).

Fishes continue to be well represented also during the Middle Ages, still with lower percentages compared to meat. The presence of fine marine species, during the 12<sup>th</sup> and 13<sup>th</sup> c., is particularly remarkable: while the consumption of freshwater fishes is better attested through the Middle Ages, still the marine life continues being fished along the coasts and being consumed in those cities tightly connected to the sea, like Rome. Several remains of turtles were found too: the animal was used during the Lent and on those other days when the meat was not allowed.

Regarding the pottery vessels, the cooking set remains the same until the Late Antiquity and includes a various number of shapes: casseroles, pans, pots and lids, which attest the coexistence of many different cooking methods. However, the cas-

serole is the predominating type, with a percentage around 80%. These are wide vessels, with diameters between 20 and 30 cm, meant for fast cooking, like frying big chunks of meat – like those provided by the *Annona* – on a layer of fat.

The set changes through the Middle Ages: the pot, previously only limitedly used, becomes almost the only type of cooking, with a percentage around 78%. The sizes also diminish, with the mouth from 8 to 12cm wide, never bigger than 14cm. This type of vessel, characterized by a rim narrower than the body, was essentially meant for long boiling cooking, like soups and broths, which witnesses a change in the diet and the cooking habits.

It is likely that other cooking methods were still used too, but the related vessels are lost because made by other materials, like metal: some sherds of soapstone cookware were found at the excavation of the *Templum Pacis*, confirming this hypothesis. The organic remains still preserved in there were analysed and showed that broths and stews were cooked inside the soapstone pots.

During the 12<sup>th</sup> c., the types of cooking ware increased again; the sizes though remained small in relation to the use of small cuts of meat. The improvement and increase of the shapes of ware show the return to a broader variety of cooking methods. The study of the living and working environment also focussed on the analysis of changes between Antiquity and the Middle Ages, investigating two important ancient monuments and shedding light on the ways in which their structures were reused in the post-ancient era for residential and working purposes.

The two sites of the Colosseum and the *Templum Pacis* were stratigraphically excavated. Concerning the Colosseum, the study focussed on reconstructing the phases of life of the site after the end of its use as an amphitheatre (Facchin, Rea, Santangeli Valenzani 2019).

The place, between the 11<sup>th</sup> and the 13<sup>th</sup> c., had many different uses and was under the property of many owners, who reused the vaulted rooms under the *cavea* as stables and warehouses. Written sources of the same period also witness the presence of higher-level dwellings (which, however, are still invisible to the archaeological evidence) and also of an aristocratic fortified residence, the fortress of the Frangipane, of which some elements started being recognized.

In the area of the *Templum Pacis*, the most meaningful results were provided by the excavation of some rooms flanking the *vicus ad Carinas*, a road which shows a rather long continuity of life, from Antiquity to the contemporary age. These spaces, most probably with a business or commercial function during the Imperial age, were transformed, during the high Middle Ages, in productive structures, linked to the use of fire for the ceramic and metal productions. This transformation is coherent with what the recent archaeological discoveries have suggested: the crisis of the urban town planning during the Late Antiquity in Rome produced a shift of the productive activities that from the suburbs entered the centre of the city (Molinari, Santangeli Valenzani, Spera 2016), with serious consequences on the health conditions of the most populated part of the city, also due to the sewage and water problems.

## **History of Medicine and Physical Anthropology: the role of transversal skills in PRIN goals**

Studies carried out thus far at an international level have been defined by poor interactivity between scientific and humanistic skillsets. The design of this research was carried out with the fundamental conviction that cross-referencing and comparing the data already partially available in historical-medical, anthropological research, in the history of religions and burial rituals, could serve, in addition to interpreting specific pathophysiological conditions, to give contextualise scientific data within a historical-cultural background in an appropriate manner.

On the other hand, the epigraphic, literary and iconographic sources, a reflection of an aristocratic perception of the world, have always helped only tangentially to reconstruct contexts attributable to marginal population groups, while biological materials have made it possible to give a voice to a segment of the population that is by definition mute, also from a historiographical point of view. Consequently, these materials represent the only objective evidence at our disposal that can be used to reconstruct the life stories of the ancient population from the historical-medical point of view.

Medical and non-medical literary sources have allowed scholar to develop a connection between the analysis of social status and diseases, as well as a description of epidemiological trends in relation to environmental archaeology and population flows, including etiological interpretations in the therapeutic systems adopted (Fornaciari et al., 2019; Iorio, Marinozzi, Gazzaniga 2018; Piccioli et al., 2015) in ancient medicine.

The analysis of medical, pharmacological and literary texts was integrated with culinary recipes provided by some authors, including descriptions of banquets and ceremonies, the use of food in medicine as a preventive regimen and in the same way the documentary sources in relation to living conditions, work, nutrition, origin, hygienic conditions, habits and customs, parental relationships, traumas and diseases that have characterised the living conditions of the population. Regarding the aforementioned work, the differences between the actual pathological conditions that were frequent in most population groups and those described by doctors for their patients, who generally belonged to an elite class of the population, were also highlighted (Gourevitch 2001; Buzzi 2019)

We refused to rely solely or primarily on historical demographic data (Virlouvet 1997), believed to provide only partial and generally approximate data.

The focus of our research on nutritional history, which includes not only the study of food itself, also included the methods of procuring raw materials, conservation techniques, the history of communication routes and transport systems, reflection on routes geographical areas of a very extensive world (which was the Roman Empire at the time of the explosion of the “Antonine” Plague), in which the movements of the armies carry, among other things, diseases and contagion (Cilione-Gazzaniga 2020).

The character of the disease that repeatedly affected the Roman territory was that of a “new” disease, attacking populations that immunologically lack the means to combat it. Specifically, in the marginal areas of the empire, the people often experienced conditions of economic hardship and housing problems.

This part of history does not always adhere to the theories of medical explanation, but also relies in late stages on popular beliefs in “contagion” – with interesting

consequences, such as that of the precautions taken to avoid the risk of pollution during burials – to oracles, magic and sacred rites. Such an articulated and detailed path within Marco Aurelio's "unnameable disaster" makes the plague the most useful paradigm of reflection on the possibility that the history of medicine has to go beyond the narrow confines of its specific competence, becoming an undeniable part of social, economic and cultural history (Duncan-Jones 1996; Harper 2017).

First and foremost, the study of History of Medicine played a role in connecting all units by facilitating scientific comparison among the research groups.

Specifically, focus was placed on the conceptualization of the body in anatomical votives and in the tradition of vascular iconography as a vehicle for the anatomical and physio-pathological theories of the contemporary medical literature (Cilione, Marinozzi, Gazzaniga, 2018).

The molecular survey of the diet, which is the main therapeutic tool in ancient medicine, has partly confirmed, albeit also partly not, the historical-medical sources of imperial age – the relationship between gender and nutrition is in fact less binding than that found between nutrition and labour activities.

On the other hand, anthropological and paleo-pathological analysis confirmed the therapeutic approaches related to bone traumatology documented in the sources.

Lastly, the comparison between anthropological, molecular and paleo-pathological data on the contexts of the spread of infectious diseases, paired with the epigraphic, legal, literary and medical sources has revealed a consistent representation of the relationship between mankind, the environment, nutrition and disease that seems to testify to a strong awareness of public health problems already in the late-republican legal texts and in the medical treaties of the Imperial Age.

A sub-unit working group (coordinated by dr. P. Catalano) shared with the all the other research units the data of a multi-year work conducted by the Anthropological Unit of the Soprintendenza Speciale per i Beni Archeologici di Roma of which the PRIN has helped to enhance scientific results in a broader perspective of historical reconstruction.

Specifically, bio-archaeological studies and historical documents have proved crucial for the reconstruction of the lifestyle and health conditions of ancient populations and have also been a valuable tool for understanding human-environment interactions over time.

Participating in the activity of territorial protection conducted by the Soprintendenza Speciale per i Beni Archeologici di Roma, the Servizio Antropologico has recorded and preserved over the years an enormous amount of data, all potentially usable to reconstruct the biological history of Roman society, especially of Imperial Age (Catalano 2015).

The in-depth analysis of the skeletal remains in the laboratory allowed us to define the life and health conditions of the population, while also assessing the incidence of degenerative, traumatic, dental, metabolic and infectious diseases in the various human groups.

Ergonomic studies have made it possible to evaluate enthesopathic alterations and degenerative joint pathologies in order to reconstruct work and labour activities, through the study of the following aspects: paleo-demography, paleopathological analysis, anthropometry, detection of musculoskeletal markers, analysis of dentoalveolar diseases and stress indicators, macroscopic analysis: CT, SEM and histology (Mosticone, Pescucci, Porreca, 2015).



In recent decades, new excavation methodologies and approaches applied to human skeletal remains have yielded considerable information on Roman burials. The PRIN has allowed to expand and go more in-depth during the laboratory investigations. This work led us to a greater understanding of the complex biological landscape represented by the population of ancient Rome, in light of the biodemographic and social processes that concerned it. The sites were selected on the basis not only of the numerical consistency, but also of the peculiarities and unique aspects of the contexts. This choice allowed us to formulate reliable hypotheses on the different subsistence economies of the reference populations.

Specifically speaking, this included: on the far eastern outskirts, along the Via Prenestina Polense, of considerable interest what is found in the site of Quarto Cappello del Prete, located not far from the ancient city of Gabii. Proceeding towards the urban center, there are the large necropolis Collatina (which stretches between Via della Serenissima and Via Basiliano, near the ancient route of the Via Collatina) and, about 1 km from Porta Maggiore, the funeral complex investigated in the district of Casal Bertone, between the streets Tiburtina and Prenestina, adjacent to a production structure. Along the Via Tuscolana, in the immediate vicinity of the Villa of the Settebassi, is located the funeral set of Osteria del Curato. To the south is the burial ground of Via Padre Semeria, a crossroads of Via Cristoforo Colombo, near the southern section of the Aurelian Walls. Finally, in the south-west, not far from Ostia Antica, (Zona Ponte Galeria), on a sandy hilly area the necropolis of Castel Malnome has been unearthed

## Conclusion

A great deal of time has passed since historians learnt how to make use of various different kinds of sources, apparently with nothing in common among one and another. This is especially true for the Empire and the Early Middle Ages, due to the vast array of archaeological materials found in the area of Rome over the last three decades and the new technological tools developed to analyse these findings. It is the notion of source itself that has likely changed. The study of everyday life allowed new evidence to enter the historian's laboratory, in which many humble objects, meaningless at first sight, started filling the shelves of the official history in order to draw a more complete image of man and woman.

The body itself has become a site to be excavated – certain lifestyles left important traces that need to be interpreted according to the traditional medical and literary written sources available.

Food, health and disease are to be examined first. Nutrition in relationship with the class or status that people belong to and the active life they lead, in terms of job practice and social roles, can provide plenty of information especially if connected to the pathological framework in which people should be placed.

Moreover, the natural and architectural environment in which humankind lived and worked literally shaped his body, turning into a treasure chest for investigation. The collaboration and teamwork of several specialists ensured a comprehensive analysis of the different factors involved in biological and cultural changes during the transition from the Empire to the early Medieval period. Research on daily life from

the beginning of the Roman Empire to the early Middle Ages in the Rome area has consequently provided new historical evidence to reconstruct a reliable image of society in those periods, enriching not only the scientific universe – through publications of papers and scientific volumes or through the organization and participation in scientific conferences – but also transforming the data emerging from the specialist's analysis of the various disciplinary groups into tools that could convey new knowledge outside pure academics. With the intent of deconstructing the more common approach of understanding ancient Rome mainly through archaeology and literary evidence, we focused more on how this culture was also made up of men and women, whose bodies can tell us a great deal about daily life, work, nutrition, healthcare and social customs of the most populous city in the ancient world.

Consequently, we decided to set up an exhibition inside the Sapienza University of Rome and then inside the Museo Nazionale Preistorico Etnografico "Luigi Pigorini" in Rome. The exhibition "Life Stories: Ancient Romans told by science" was made up of several exhibits of complete or partial skeletal reconstruction, developed as case studies that identify the physiognomy of an individual in Rome due to their biological specificity, eating and socio-cultural habits, able to tell the visitor in detail individual life stories.

They have given voice back to abused women, mothers and children, the elderly and workers who, through the signs of the body, tell us about living conditions, work, food, origin, hygienic conditions, habits and customs, parental relationships, trauma, diseases and medical treatments that defined their existence.

The narratives of everyday life were accompanied by the data and the related scientific techniques used to achieve them. This work was an attempt to give substance to the idea of a musealization as a dynamic centre that shows and tells the story of an ancient civilization, explaining with what techniques and what tools it was able to reconstruct it, which therefore plays an active role in the spread and awareness of cultural understanding, as well as scientific and didactic training within society.

## References

- Allison P.M., (2004) *Pompeian Households: an Analysis of Material Culture*. Cotsen Institute of Archaeology, University of California, Los Angeles.
- Alabdullrahman L.W., Byerly D.W. (2021) Osteochondroma. StatPearl, August 15.
- Bianucci et al., (2015) The identification of malaria in paleopathology-An in-depth assessment of the strategies to detect malaria in ancient remains. *Acta Tropica* 152: 176-180.
- Bowes K., (2010) *Houses and Society in the Later Roman Empire*. Duckworth, London.
- Buikstra J.E. (2019) *Ortner's identification of pathological conditions in human skeletal remains*. New York, Academic Press.
- Buzzi S., (2019) Galeno e le sue pazienti: analisi di alcuni casi clinici, *Semitica e Classica* 2019; 12: 109-127.
- Caldarini C., Zavaroni F., Benassi V. (2015) Musculoskeletal Markers, Arthropaty, Traumas. *Medicina Nei Secoli*. 27(3), 905–967.
- Catalano P., (2010) *Attività lavorative e condizioni di vita della comunità di Castel*

- Malnome (Roma, I – II sec. d.C.). *Medicina nei Secoli* 22 (1-3): 111-128.
- Catalano P., (2015). What Skeletons Tell Us. *Medicina nei Secoli*. 27(3), 773–785.
- Catalano P., Gazzaniga V. (2019) A remarkable case of gout in the Imperial Rome: Surgery and diseases in antiquity by osteoarchaeological, paleopathological, and historical perspectives. *International Journal of Osteoarchaeology*. 5: 797-807.
- Cesana et al., 2017. The origin and early spread of the Black Death in Italy: first evidence of plague victims from 14th-century Liguria (northern Italy). *Anthropological Science* 125: 15-24.
- Cilione M., e V. Gazzaniga, V.(2020) Tempo di epidemie ed epidemia nel tempo: un approccio storico-medico al racconto delle pestilenze, in A. Jori (ed), *I cavalieri dell'Apocalisse. Le epidemie tra medicina, storia, filosofia e arte*, Palermo, Nuova Ipsa Editore, 2020, 105-114.
- Cilione M., (2016) Abortive Pollution in the Sacred Laws of Cyrene and Kos. *Medicina nei Secoli*. 28, 1: 19-38.
- Cilione M., Marinozzi S., Gazzaniga V., (2018) Feet and fertility in the healing temples: a symbolic communication system between gods and men. *Med Humanit* June. 45, 1: 1-6.
- S.K. Cohn Jr S.K.. (2018), *Ancient Epidemics. What the Oracles had to say*, Oxford Scholarship online., 2018.
- De Angelis F, Varano S, Battistini A, Di Giannantonio S, Ricci P, Lubritto C, Facchin G, Brancazi L, Santangeli-Valenzani R, Catalano P, Gazzaniga V, Rickards O, Martínez-Labarga C., (2020a). food at the heart of the empire: dietary reconstruction for imperial Rome inhabitants. *Archaeological and Anthropological Sciences*, 12.
- De Angelis F, Romboni M., Veltre V., Catalano P., Martínez-Labarga C., Gazzaniga V., Rickards O. (2022). First Glimpse into the Genomic Characterization of People from the Imperial Roman Community of Casal Bertone (Rome, First–Third Centuries AD). *Genes*, 13.
- De Angelis F, Veltre V., Romboni M., Di Corcia T., Scano G., Martínez-Labarga C., Catalano P., Rickards O., (submitted) Ancient genomes from a rural site in the Imperial Rome (1<sup>st</sup>-3<sup>rd</sup> cent. CE): a genetic junction in the Roman Empire. *Annals of Human Biology* (1<sup>st</sup> revision).
- De Angelis F, Veltre V., Romboni M., Di Corcia T., Scano G., Martínez-Labarga C., Catalano P., Rickards O. (2021). Ancient genomes from a rural site in Imperial Rome (1<sup>st</sup>–3<sup>rd</sup> cent. CE): a genetic junction in the Roman Empire. *Ann. Hum.Biol*, 48, 234-246.
- De Angelis F, Veltre V., Varano S., Romboni M., Renzi S., Zingale S., Ricci P., Caldarini C., Giannantonio S. D., Lubritto C., Catalano P., Rickards O., & Martínez-Labarga C., (2020) Dietary and Weaning Habits of the Roman Community of Quarto Cappello del Prete (Rome, 1<sup>st</sup>-3<sup>rd</sup> Century CE). *Environmental Archaeology*. 1–15.
- De Angelis F, Veltre V., Varano S., Romboni M., Renzi S., Zingale S., Ricci P., Caldarini C., Giannantonio S. D., Lubritto C., Catalano P., Rickards O., Martínez-Labarga C. (2020b). Dietary and Weaning Habits of the Roman Community of Quarto Cappello del Prete (Rome, 1<sup>st</sup>-3<sup>rd</sup> Century CE). *Environmental Archaeology*, 1-15.
- De Grossi Mazzorin J., (2016) Lo sfruttamento degli animali domestici a Roma e nel Lazio nel Medioevo. *L'Archeologia della produzione a Roma (secoli V-XV)*. Biblio-

- theca Archaeologica 50, Bari.
- Duncan-Jones R. P., (1996) The impact of the Antonine Plague, *Journal of Roman Archaeology* 1996; 9: 108-136.
- Facchin G., Rea R., Santangeli Valenzani R., (2019) Anfiteatro Flavio. Riusi e Trasformazioni. Electa, Milano.
- Fornaciari G., Marinozzi S., Messineo D., Caldarini C., Zavorini F., Iorio S., Sveva L., Capuani L., Fronza V., Santangeli Valenzani R. (2020) Tecniche costruttive dell'edilizia residenziale tardo antica e altomedievale. *Archeologia cristiana, metodologie e cultura materiale della tarda Antichità e dell'Alto Medioevo*. Pontificio Istituto di Archeologia Cristiana, Roma.
- Galetti P. (2010) *Edilizia residenziale tra IX e X secolo*. Storia e archeologia, Firenze.
- Giuffra FV., Fornaciari G. (2021) *Fondamenti di Paleopatologia*. Pisa University Press, Pisa.
- Gourevitch D. (2001) *I giovani pazienti di Galeno: studio per una patocenosi dell'impero romano*, Laterza, Roma.
- Gourevitch D.D, (2011) *Pour une archeologie de la medicine romaine*. De Boccard, Paris.
- Grmek, M.D., (1969) *Préliminaires d'une étude historique (des maladies)*. Annales Économies, Sociétés, Civilisations, Paris.
- Guidobaldi F. (1986) *L'edilizia abitativa unifamiliare nella Roma Tardoantica*. Società Romana e Impero Tardoantico, vol. II, Roma. Politica, economia, paesaggio urbano. Laterza, Roma-Bari.
- Hillson S. (1996), *Dental anthropology*, Cambridge, Cambridge University Press, 1996.
- Iorio S., Marinozzi S., Gazzaniga V. (2018) Healing bodies: The ancient origins of massages and Roman practices. *Medicina Historica*. 2(2): 58-62.
- Meyer M, & Kircher M. (2012) Illumina sequencing library preparation for highly multiplexed target capture and sequencing. *Cold Spring Harb Protoc*. Cold Spring Harb Protoc; 2010; doi: 10.1101/pdb.prot5448.
- Minozzi S., Fornaciari G. (2015) Paleopathology of Human Remains. *Medicina nei Secoli*. 27(3), 1043–1065
- Minozzi S., Caldarini C., Pantano W., Di Giannantonio S., Catalano P., Giuffra V. (2020), Enamel hypoplasia and health conditions through social status in the Roman Imperial Age (1st-3rd centuries, Rome, Italy), in «*International Journal of Osteoarchaeology*», 30, 2020;, pp. 53-64
- Minozzi S., Lunardini A., Caldarini C., Caramella D., Fornaciari G., Catalano P., Giuffra V. (2018) Metastatic Prostate Carcinoma from Imperial Rome (1st to 2nd Centuries AD). *Pathobiology*. 85: 289-299.
- Mion L., Herrscher E., André G., Hernandez J., Donat R., Fabre M., Forest V., Salazar-Garcia D.C. (2019) The influence of religious identity and socio-economic status on diet over time, an example from medieval France. *Archaeol Anthropol Sci* 11:3309–3327
- Molinari A., Santangeli Valenzani R., Spera L. (2016) *L'Archeologia della produzione a Roma (secoli V-XV)*. Edipuglia, Bari.
- Montanari M. (1979) *L'alimentazione contadina nell'alto Medioevo*. Liguori, Napoli.
- Mosticone R., Pescucci L., Porreca F. (2015) Life Conditions: non-Specific Stress Indicators and Dentoalveolar Pathologies. *Medicina nei Secoli*, 27(3), 969–1042.

- Musco S., & Catalano P. (2010) Tombes d'enfants de l'époque impériale dans la banlieue de Rome: Les cas de Quarto Cappello del Prete, de Casal Bertone et de la nécropole Collatina. In *L'enfant et la mort dans l'antiquité (387–402)*. De Boccard, Paris.
- Piccioli A., Gazzaniga V., Catalano P. (2015) Bones. Orthopaedic Pathologies in Roman Imperial Age. Springer.
- Pounds N.J.G. (2014) An economic history of medieval Europe. Taylor & Francis, London
- Priester S. (2002) Ad summas tegulas. Untersuchungen zu viegelschossigen Gebäudelblöcken mit Wohneinheiten und Insulae im Kaiserzeitlichen Rom. L'Erma di Bretschneider, Roma.
- Riccomi G., Minozzi S., Pantano W., Catalano P., Aringhieri G., Giuffra V. (2018) Paleopathological evidence of paranasal lesions: Two cases of frontal sinus osteomata from Imperial Rome. *International Journal of Paleopathology*. 20: 60–64.
- Salvadori F. (2015) Uomini e animali nel Medioevo. VDM Verlag, Berlin.
- Séguy I. (2019) Current Trends in Roman Demography and Empirical Approaches to the Dynamics of the Limes Populations, in: Verhagen, P., Joyce, J., Groenhuijzen, M. (2019) Finding the Limits of the Limes. Computational Social Sciences. Springer .
- Siegel R.L., Miller K.D., Jemal A. (2020) Cancer statistics. *Cancer Journal for Clinicians*.s, 707-30.
- Tartaglia G., Nava A. (2015) Osteometric Analysis. *Medicina Nei Secoli*. 27(3), 873–904.
- Varano S., De Angelis F., Battistini A., Brancazi L., Pantano W., Ricci P., Romboni M., Catalano P., Gazzaniga V., Lubritto C., Santangeli Valenzani R., Martínez-Labarga C., & Rickards O. (2020) The edge of the Empire: Diet characterization of medieval Rome through stable isotope analysis. *Archaeological and Anthropological Sciences*. 12(8): 196.
- Virlouvet C. (1997) La Rome impériale. Démographie et logistique, CEFR 230, Roma. 1997.