

ARTICLE

# Ca' Granda, an avant-garde hospital between the Renaissance and Modern age: a unique scenario in European history

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## Abstract

The *Ospedale Maggiore*, known as *Ca' Granda*, was founded in 1456 by will of Francesco Sforza, Duke of Milan, and was considered for almost five centuries a model for Milanese, Italian and even European healthcare. Attracting patients from all over Europe, the *Ca' Granda* distinguished itself for the introduction of new treatments and innovative health reforms. In the burial ground of the hospital still lie the bodies of the deceased patients, who came from the poorest strata of the population. The study of their remains aims to give back a general identity and a story to each of these persons as well as reconstruct a fraction of the sixteenth century population of Milano as concerns lifestyle and disease and examine practises and therapy of this exceptional hospital. It is estimated that about two million commingled bones and articulated skeletons rest in the crypt, together with other types of findings (e.g., ceramic, coins, clothing). These remains are the object of a large project involving various disciplines ranging from humanities to hard sciences. The aim of this paper is to bring this historical gem to the attention of scholars and provide a glimpse of what its contents have already revealed.

**Keywords:** Hospital; History of medicine; Archaeology; Anthropology; Renaissance; Modern era

## The Ca' Granda

### The Ca' Granda hospital

The land necessary for the construction of the hospital was donated by the *condottiero* and Duke of Milan Francesco Sforza in 1456 marked the foundation of the *Ospedale Maggiore*. Its creation was set in a context of reformation of the healthcare facilities between the fourteenth and fifteenth centuries in Italy, characterised by the reorganisation and merging of numerous agencies into a single healthcare organisation.<sup>1</sup> This led to the construction of the *Ospedale Maggiore*, affectionately called *Ca' Granda* (a nickname for 'Casa Grande' or 'Big Factory') by the Milanese due to its massive dimensions following Sforza's wishes. Antonio Averlino, known as 'Il Filarete', was the architect of the hospital until 1465. Adopting the model of various Tuscan hospitals, he designed a rectangular building composed of two symmetrical square bodies, divided by four aisles arranged in a Greek cross. According to the initial idea, one of these so-called '*crociere*' was reserved for men (on the right) and one for women (on the left) and gave life to eight internal courtyards. An altar was placed at the crossing point of the wards so that the patients could observe the sacred images and the assistants could maintain control over the area. Each arm of the *crociera* was about 10 m high and lined with windows; the beds were organised into two parallel rows with their headboard resting against the wall. In the middle of the structure, a rectangular courtyard separated the two symmetrical bodies with a marble church at its centre, covered with mosaics. Following the example of the hospitals in Siena and Florence, mediaeval medical institutions were always built near waterways. The Ca' Granda represents the first hospital where water canalization was used to supply and maintain high hygiene standards. In fact, the most innovative aspect of the hospital's architecture was the '*Destri*', or rooms for toilets. These rooms were arranged along the entire perimeter of the hospital and were provided with an entrance every two beds. Thanks to a system of canalizations for the flow of water to and from the *Naviglio* (the artificial canal in Milan), the *destri* allowed for the disposal of urine, faeces and other waste limiting the risk of contaminating the patients. In addition, the underground tunnels gave access to various structures, such as the laundry room, essential for the hospital's daily life (Figure 1).

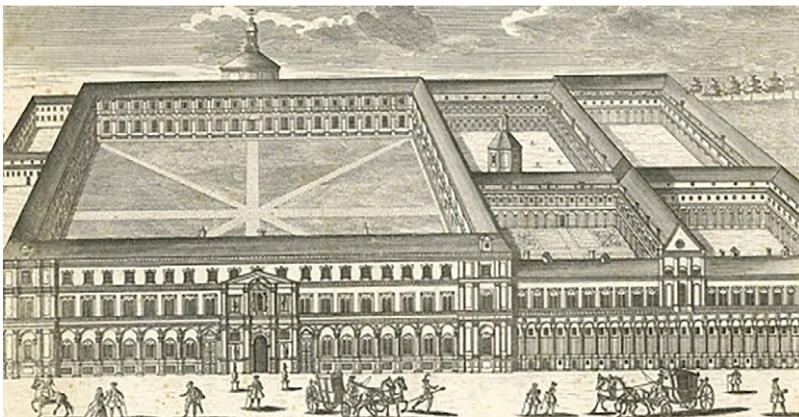


Figure 1. F.B. Werner, *Veduta della Ca' Granda nel 1740*, engraving from the Archivio dell'Ospedale Maggiore Ca' Granda Policlinico, Milan.

<sup>1</sup>Giuliana Albini, *Carità e Governo Delle Povertà (Secoli XII–XV). Introduzione* (Milan: Unicopli, 2002); Giorgio Cosmacini, *La Carità e La Cura: L'Ospedale Maggiore Di Milano Nell'età Moderna* (Milan: Ospedale Maggiore Di Milano, 1992); Giorgio Cosmacini, *La Ca'Granda Dei Milanesi: Storia Dell'Ospedale Maggiore* (Rome: Laterza, 1999); Giorgio Cosmacini, *Biografia Della Ca'Granda: Uomini e Idee Dell'Ospedale Maggiore Di Milano* (Rome: Laterza, 2001); Folco Vaglianti and Cristina Cattaneo, *La Popolazione Di Milano Dal Rinascimento: Fonti Documentarie e Fonti Materiali per Un Nuovo Umanesimo Scientifico* (Milan: Edizioni Biblioteca Francescana, 2013), 13–23.



**Figure 2.** Lombard painter, *Il cortile dell'Ospedale Maggiore*, circa 1670–1690, oil on canvas, quadreria dell'Ospedale Maggiore di Milano, Milan.

The institution of the *Ospedale Maggiore* also gave way to a reformation of the Milanese hospital system. Indeed, it not only aimed at the social control of poverty, marginalisation, and deviance, but it also became the centre of a system composed of fourteen other minor health centres (seven religious, one administered by a civil committee and six with mixed administration). This reform involved juridical-administrative changes, with new rules that clearly established all tasks, functions, and behaviours of the administrators, as well as ethical-economic principles, where assistance became less spiritual and more clinical, and the aim was not only to immediately improve the health of patients but also to reintroduce them into the labour market and society.<sup>2</sup> Through this reform, a new social and health network was created: in this new hospital, the patients suffering from acute conditions were admitted, whereas the patients suffering from disabilities, chronic and incurable diseases (i.e., whose health could not be fully recovered), were treated in the aggregated decentralised structures (i.e., the minor hospitals). The *Ca' Granda* welcomed patients with acute medical or surgical conditions, as well as citizens of low social class with no specific ailment but suffering merely from starvation, which explains why the number of hospitalised patients increased very quickly (Figure 2).

From the inauguration of the hospital, each wing of the *crociera* was specialised in the treatment of a given pathology. Despite the heterogeneity of the pathological conditions of the patients, each was treated with a specific therapy by doctors and surgeons specialising in various diseases such as syphilis (also called 'brossole disease' or 'mal franzese'), 'mal di pietra' (bladder stones), 'tigna favosa' (the term used for scabies, a condition affecting the scalp, skin, or nails) and hernias. Admission to the hospital was decided on the basis of financial means and not health conditions: the patient had to show a 'faith of poverty' (through a document in which he or she swore to be poor because of ill fortune or '*povertà laboriosa*') and the council hence decided on the admission to the facility. At the end of the fifteenth century, doctors and surgeons began to access the hospital wards (previously the task of assisting the patients was reserved to priests and nurses). In the early years of the sixteenth century, doctors and surgeons took full charge of caring for the patients. They were also in charge of admission and the equivalent of today's *triage* (diagnosis and sorting of patients). Such 'health charity' thus shifted to 'assistance' conceived as care but above all as therapy, in order to return healthy individuals to society and remove the incurable: in this sense, the hospital became a true health factory, hence the name *Ca' Granda* (as previously mentioned).<sup>3</sup>

<sup>2</sup>Giuliana Albini, *Città e Ospedali Nella Lombardia Medievale* (Bologna: Clueb, 1993).

<sup>3</sup>Cosmacini, *op. cit.* (note 1); Cosmacini, *op. cit.* (note 1).

In addition, the hospital possessed vast lands, which were used as a source of income and to provide useful resources for both the refectory and pharmacy.

Dating back to the foundation of the hospital, the archives of the *Ca' Granda* contain all the economic and administrative documents relative to its management until the closure of the hospital. These documents reveal which plants were used for the treatment of patients, new medical techniques and the type and specialisation of all the medical staff. In addition, the *pharmacopoeia* of the hospital is still available and is a fundamental part of the ongoing research. Since the fifteenth century, the pharmacopoeia of the ancient hospital of Milan listed all plants and substances used for the preparation of the therapeutic remedies (such as ointments, compresses, decoctions, etc.) with a meticulous account of the medicinal inventory including dosage and frequency for specific conditions. Finally, the documents and reports concerning the food and care of patients detail the everyday life of the ill as well as that of the doctors who worked daily at the *Ca' Granda*.

### **The *Ca' Granda* crypt**

The sixteenth century saw the *Ca' Granda* emerge as one of the main institutions of Milan benefitting from the growing support of substantial private donations.

In fact, tax relief by the city governor facilitated donations to the structure and refectory. In 1624, the church of the *Beata Vergine Annunciata* (or *Santa Maria Annunciata*) was instituted within the hospital grounds with the creation of an underground crypt.<sup>4</sup> The church, and in particular the crypt, became the place of burial of those who died in the hospital from 1637, with the construction of sepulchral chambers in 1634 below the crypt of the church (Figure 3).

The architects designed the crypt to bury the corpses inside the underground chambers where they were to decompose and skeletonise. Once the chambers became full of osseous remains, the bones were displaced in a cemetery area (called *fopponi* in Milanese dialect) within the hospital grounds. Nonetheless, the new sepulchral spaces were insufficient because of the increase in the number of patients (due to the expansion of the hospital) and the concomitant increase in the number of deaths. Furthermore, available burial space became a constraint due to the impossibility of proceeding regularly with the emptying of the sepulchral chambers, whose construction had placed them in close contact with an aquifer, thus creating an atypical microclimate which slowed down the decomposition processes. This emergency, together with the pestilential smells that developed from the crypt, made it necessary in 1698, to build a new cemetery area outside the *Ca' Granda* (*San Michele ai Nuovi Sepolcri*, now known as *Rotonda della Besana*).<sup>5</sup> Consequently, from 1697, the remains of the deceased patients were no longer deposited in the crypt of the hospital, but in a new and dedicated location further away from the living, in a suburban area of the city. Hence, the remains contained in the crypt today should refer to the period between 1637 and 1698 and represent 50 years of the life of the hospital, and of the Milanese population of the seventeenth century.

However, the remains of the *Ca' Granda* crypt did not stay undisturbed until 2009: in 1848, during the insurrections of the historical Five days of Milano (*Cinque Giornate*) which started the First Italian War of Independence, it was not possible to bury the bodies of the fallen outside of the city. This led to the reuse of five of the antique chambers of the crypt of the *Ca' Granda*. The bones already present were moved to different chambers and so these patients may still 'contaminate' the original remains of the crypt.<sup>6</sup> Finally,

<sup>4</sup>Giovanni Agosti and Jacopo Stoppa, *La Ca'Granda: Da Ospedale a Università: Atlante Storico-Artistico*, Vol. 6 (Rome: Officina Libraria, 2017), 67–71; Cosmacini, *op. cit.* (note 1); Cosmacini, *op. cit.* (note 1).

<sup>5</sup>Mariangela Carlessi and Alessandra Kluzer, *Il Cuore Dell'antico Ospedale Maggiore Di Milano, I Luoghi Dell'Archivio e La Chiesa Della Beata Vergine Annunciata* (Milan: Silvana Editoriale, 2011); Cesare Staurenghi, *L'Ospedale Maggiore Di Milano E I Suoi Antichi Sepolcri: Particolarmente Il Foppone Ora Detto La Rotonda Cronistoria Milanese Dei Secoli XV–XX* (Milan: Ulrico Hoepli, 1916); Vaglianti and Cattaneo, *op. cit.* (note 1).

<sup>6</sup>Staurenghi, *op. cit.* (note 5).

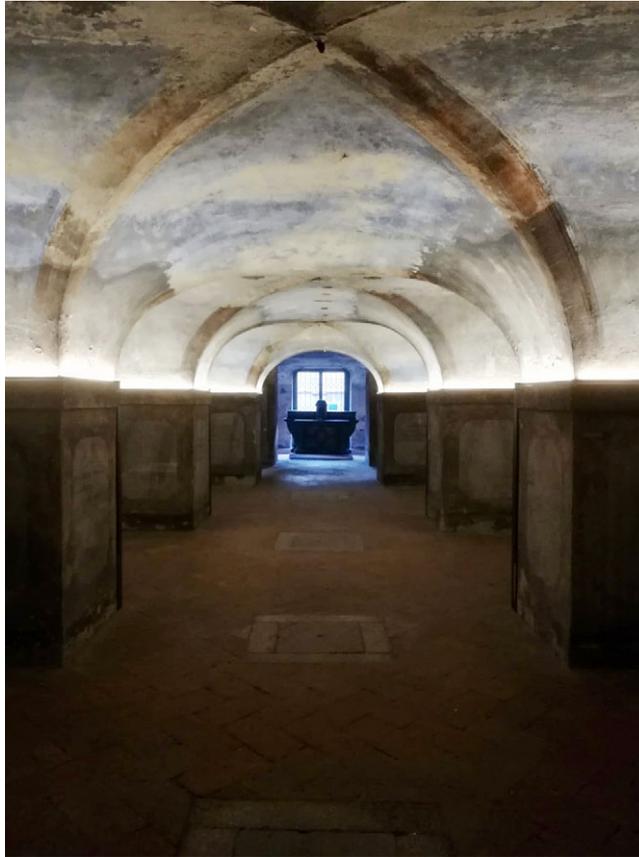


Figure 3. View of the inside of the crypt of the *Beata Vergine Anunciata*, below the Ca' Granda hospital.

in 1943, during the Second World War, the bombings over Milan destroyed the *Ca' Granda* and damaged part of the crypt.<sup>7</sup>

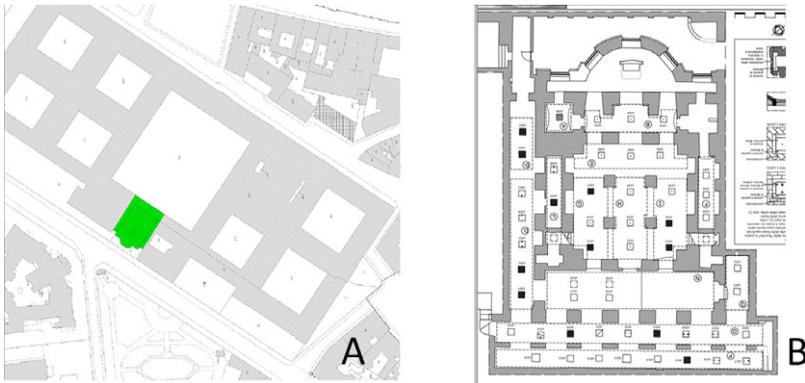
The Ca' Granda hospital and its crypt filled with the remains of the ancient patients could represent (with some contamination) not only a glimpse of the past but also a unique monument for reading the history of medicine and its applications. The successes (and failures) of this art, which can be analysed here, may help us better understand the efforts implemented over time that allowed us to reach the science we know today.

### ***The Crypt and the Ca' Granda Project***

The Ca' Granda Project, which first started in 2010,<sup>8</sup> represents an initiative taken by the University of Milan and the *Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico* and is currently funded mainly by *Regione Lombardia*. The aim is to restore the crypt, excavate and study the remains and finally open its spaces and the results of scientific research involving archaeologists, historians, anthropologists, toxicologists, botanists, data scientists and entomologists to the scientific community as well as to the general public.

<sup>7</sup>Agosti and Stoppa, *op. cit.* (note 4).

<sup>8</sup>Francesca Vaglianti and Cristina Cattaneo, 'A Medieval Contribution to the History of Legal Medicine: The First European Necroscopic Registry', *International Journal of Legal Medicine*, 124, 6 (2010), 669–70.



**Figure 4.** (a) Representation of the Ca' Granda hospital (Catasto Urbano di Milano, Foglio 438, Particella 61), and the crypt (b) from the Archivio dell'Ospedale Maggiore Ca' Granda Policlinico, Milan.

The crypt of the *Ca' Granda* has 14 sepulchral chambers with a total surface area of 365 m<sup>2</sup> (Figure 4a). Each chamber is accessible through 50 cm large square manholes. The chambers have different sizes, with openings ranging from a single manhole (chamber A) to nine manholes (chamber O). Chamber O was the first to be investigated thanks to a large opening due to the destruction of a wall during World War II bombings. The chambers are about 2.20 m high, and the level of the fill reaches about half the height (Figure 4b). Below the manhole, there are anthropic conoid accumulations composed of bones and sometimes ruins (bricks, wooden tables, nails, rubble) due to wars and restoration of the building.

During the archaeological investigations, surveys were carried out to determine the internal situation of the chambers and to observe the accumulation of anthropological (bones, hardened and mummified soft tissues, skin appendages, etc.) and archaeological (jewellery, clothing, coins, pottery, etc.) remains and the structure of the chambers themselves (Figure 5). The stratigraphic excavation, supported by important activities such as photogrammetry and 3D surveys, is leading to the discovery of different mechanisms and phases of deposition of the corpses in the chambers as well as anthropogenic events (such as continuous lime pours) aimed, in vain, at accelerating the decomposition processes (Figure 6).

In the chambers, a large portion of the remains of the patients are commingled: this is due to the long-standing use of the sepulchral chambers for almost a century and to the anthropogenic interventions to make room for the ever-increasing quantity of dead to be deposited. However, in the lower layers of the excavations, partially or entirely articulated skeletonised bodies have also been recovered, which demonstrates their primary deposition. Indeed, these findings are fundamental indicators of the deposition of intact cadavers directly from the mortuary (called *brugna* in Milanese dialect) of the hospital, and not, as has been asserted for decades by historians, of already skeletonised and commingled remains. In fact, the current archaeological investigations are proving that indeed the crypt was both a primary and secondary site of deposition.

### ***Preliminary results of the multidisciplinary analysis of the remains***

So far, over 300 000 bones have been studied from all sepulchral chambers: preliminary anthropological osteological analyses have shown there to be an almost equal distribution of males and females of all ages (ranging from third trimester fetuses to older adults),<sup>9</sup> proving how the hospital catered for all, from pregnant women or ill new-borns to the elderly. In depth osteological analyses on the ancestry

<sup>9</sup>Lane Anderson Beck, 'Standards for Data Collection from Human Skeletal Remains. Edited by Jane E. Buikstra and Douglas H. Ubelaker. 272 pp. Fayetteville: Arkansas Archeological Survey Research Series No. 44, 1994. \$25.00 (Paper)', *American Journal of Human Biology*, 7, 5 (1995), 672, <https://doi.org/10.1002/ajhb.1310070519>.



**Figure 5.** Details of the skeletal remains in the crypt. Top image, photogrammetry, and 3D reconstruction of Chamber D2; bottom image, photograph of Chamber O.



**Figure 6.** Archaeologists and anthropologists during a survey in a sepulchral chamber.



**Figure 7.** Details of pathological cases: on the left, humeral-ulnar ankylosis due to rheumatoid arthritis; on the right, osteomyelitis of a tibia with detail of the cloaca.

of the crania<sup>10</sup> show that individuals were predominantly of European origin as expected; however, a comparative analysis between this seventeenth century population and the current Milanese population has shown secular changes<sup>11</sup>: heads and faces in the seventeenth century were somewhat smaller and more gracile than those seen in Italy today. The preliminary results of palaeopathological analyses confirm that the individuals present in the crypt belonged to the poor classes (specifically catered for the Ca' Granda administration of the Modern Age society), as proven by the presence of stress markers, including *cribra orbitalia* and enamel hypoplasia (which represent respectively iron deficiency and events of arrested growth during childhood due to periods of stress, disease or malnutrition).<sup>12</sup> They also revealed the presence of several morbid and debilitating conditions (e.g., painful joint diseases with reduced mobility, tertiary venereal syphilis, dental diseases showing poor buccal hygiene) as well as traumatic lesions due to falls, arduous activity or interpersonal violence<sup>13</sup> (Figure 7). Interestingly, signs of both autopsy (craniotomy) and surgery carried out within the health facility were found among the skeletal remains of the crypt.

The anthropological observations and analyses are recorded in Commingled Remains Analytics (CoRA), a cloud-based software application,<sup>14</sup> in order to collect and process the huge amount of skeletal data from the ancient hospital site. Data aggregation following a common ontology allows us to propose and test reassociation of commingled remains into individuals and hence gain a better understanding of how many and who are interred in the sepulchral chambers of the Ca' Granda crypt.

In addition, soft tissue residues of desiccated brain were recovered within the crania, which was confirmed by the presence of cellular neurological structures viewed under 40× magnification.

<sup>10</sup>Joseph T. Hefner, 'Cranial Nonmetric Variation and Estimating Ancestry', *Journal of Forensic Sciences*, 54, 5 (2009), 985–95; Joseph T. Hefner and Stephen D. Ousley, 'Statistical Classification Methods for Estimating Ancestry Using Morphoscopic Traits', *Journal of Forensic Sciences*, 59, 4 (2014), 883–90.

<sup>11</sup>Cristina Cattaneo *et al.*, 'A Modern Documented Italian Identified Skeletal Collection of 2127 Skeletons: The CAL Milano Cemetery Skeletal Collection', *Forensic Science International*, 287 (2018), 219.e1–e5.

<sup>12</sup>Arthur C. Aufderheide and Conrado Rodríguez-Martín, *The Cambridge Encyclopedia of Human Paleopathology* (Cambridge: Cambridge University Press, 1998); Jane E. Buikstra, *Ortner's Identification of Pathological Conditions in Human Skeletal Remains* (San Diego: Academic Press, 2019); Donald J. Ortner, *Identification of Pathological Conditions in Human Skeletal Remains*, 3rd edn (New York: Smithsonian Institution Press, 2003); Tony Waldron, *Palaeopathology* (Cambridge: Cambridge University Press, 2008).

<sup>13</sup>Folco Vaglianti, 'Pratica Anatomica Ospedaliera a Milano Al Tempo Di Leonardo', *Mefisto*, 4, 1 (2020), 147–64; Vaglianti and Cattaneo, *op. cit.* (note 8).

<sup>14</sup>Sachin S. Pawaskar and Franklin E. Damann, 'Commingled Remains Analytics (CoRA)', <https://www.coracore.org/>.

Chemical–toxicological analyses of soft and hard tissues have begun to inform us on the presence of lead<sup>15</sup> and mercury<sup>16</sup> as well as other substances that may have been used as a form of patient treatment. Future toxicological results will be confronted to the carefully preserved and extensively detailed pharmacopoeia of the hospital in order to confirm the written source and/or implement it with novel information concerning ‘drugs’ which, for some reason, were given to patients but not registered in the archives. The combination of information (written and osteo-toxicological) can give us a better understanding of treatment available for the poor classes of Milan. Similarly, ancient DNA analyses have been undertaken to reconstruct the complete profile (including the phenotype) of some of these deceased patients as well as possibly infecting pathogens. Pedological and sedimentological analyses will investigate the methods of anthropic activity in the sepulchral chambers. Examination of findings of material culture, mostly relating to the Christian-Catholic faith (e.g., wooden and copper alloy objects), but also footwear, rings, coins (e.g., French and Venetian) and pottery (mostly apothecary vases) will provide information regarding the individuals buried in the crypt (apparently from the lower classes of the population) and by extension the society of the period, which has hardly been investigated archaeologically.

Finally, to better understand the phases and methods of deposition of the bodies, naturalistic residues (e.g., leaves, roots, entomological and faunal findings) are currently being analysed. Botanical analyses are also fundamental to reconstruct the diet through the study of dental calculus. A recent study on starch grains trapped within the calculus of these skeletons revealed high frequencies of cereals, such as barley, rye and spelt, as well as legumes, in particular lentils and broad bean, along with a less common occurrence of corn, rice, millet, durum wheat, buckwheat, pea, and chestnut. These findings are in line with historical sources on the diet of the poor classes of Milan, which was mainly composed of ‘brown bread’, a mix of rye, spelt and barley, and legumes. Interestingly, we also found traces of *Equisetum arvense*, commonly known as ‘horsetail’, a plant whose sterile stems were used to clean dishes and for oral hygiene (like a toothbrush). However, the presence of these spores could indicate the consumption of this plant as food, especially in times of famine.<sup>17</sup>

Although all these data are still under study and contextualization, both with the historical and archaeological data and with the immense archival heritage of the Ca’ Granda, they prove the substantial amount of information that may be extrapolated from the study of the skeletal remains lying in the sepulchral chambers of the Ca’ Granda crypt.

## Conclusion

In the sepulchral chambers of the *Ca’ Granda*, now home to the University of Milan but whose hospital origins are clearly visible to those who walk in its courtyards, lies a cultural heritage of enormous value. Thanks to an ongoing multidisciplinary project, this heritage is beginning to provide insight into ancient medical practises and patient life history. In fact, the examination of these skeletons, who represent the ill and deceased patients of the hospital and on which, through trial and error, modern medicine was born, provides a glimpse not only of this specific hospital but also of an ancient era. For this reason, the authors wish to present this scientific and cultural monument to the scientific and historical community.

**Acknowledgements.** The authors would like to thank the Lombardy Region for their financial support, Dr Monica Abbiati for her constant technical support as well as the administrative offices of the University of Milan and the ‘Fondazione IRCCS Ospedale Ca’ Granda Ospedale Maggiore Policlinico di Milano’ for making its scientific and archival heritage available.

<sup>15</sup>Emanuela Sguazza *et al.*, ‘The Role of Toxicological Analyses in Anthropology: A Case Report on Lead Intoxication’, *Archaeometry*, 58, 1 (2016), 152–8.

<sup>16</sup>Lucie Biehler-Gomez *et al.*, ‘Mercury Poisoning in Two Patients with Tertiary Syphilis from the Ca’ Granda Hospital (17th Century Milan)’, *Archaeometry*, <https://doi.org/10.1111/arc.12721>.

<sup>17</sup>Mirko Mattia *et al.*, ‘“Man Is What He Eats”. Plant Residues from Dental Calculus in the Ancient Population of Milano from Roman Times to Modern Age’, *Journal of Archaeological Science: Reports*, 39 (2021), 103180.

**Competing interest.** The authors have no competing interests to declare.

**Funding.** This project has been funded by the Lombardy Region for three years (*Bando anno 2018 per la promozione di interventi di valorizzazione di aree archeologiche, siti iscritti o candidati alla lista UNESCO e itinerari culturali in Lombardia – artt. 17, 18 e 20 l.r. 25/2016*).

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**Cite this article:** Mattia M, Biehler-Gomez L, Sguazza E, Galimberti PM, Vaglianti F, Gibelli D, Poppa P, Caccia G, Caccianiga M, Vanin S, Manthey L, Jantz RL, Di Candia D, Maderna E, Albini G, Pawaskar S, Damann F, Fedeli AM, Belgiovine E, Capuzzo D, Slavazzi F, Cattaneo C (2022). Ca' Granda, an avant-garde hospital between the Renaissance and Modern age: a unique scenario in European history. *Medical History* 66: 24–33, <https://doi.org/10.1017/mdh.2021.40>