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Teaching with human remains: curatorship, technological innovation and ethical engagement at the Morgagni Museum of Human Anatomy

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Summary
Medical museums are increasingly challenged to balance accessibility, educational effectiveness, and ethical responsibility, particularly when displaying human remains. Despite growing interest in digital museology, limited attention has been paid to its application in contexts involving culturally sensitive materials.
This study presents a qualitative case study of the renovation of the Morgagni Museum of Human Anatomy (University of Padua), focusing on the integration of digital tools, including quick response codes, augmented reality (AR), and virtual itineraries. The project aimed to enhance accessibility and public engagement while preserving the scientific and ethical integrity of the collection. The results, based on observational data collected during guided visits and educational activities, indicate that hybrid interpretive strategies combining digital and traditional tools improve visitor engagement, support layered learning, and foster a more informed interaction with anatomical and pathological specimens. In particular, the use of AR and digital content was associated with increased student participation and enhanced observational skills. This case study demonstrates that digital technologies, when embedded within a coherent curatorial framework, can strengthen rather than diminish ethical engagement with human remains. The Morgagni Museum provides a model for the sustainable and responsible reinterpretation of historical medical collections in contemporary educational contexts.

Keywords: History of medicine, Human Remains, Museums, New technology for museums

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Introduction

Starting from the 18th century there was a development from the Wunderkammern or Cabinet of Curiosities to the creation of real museums with scientific purposes. Medical museology soon began to demonstrate its educational abilities in the anatomical and pathological fields, having collections open not only for scholars and students but also for the general public. Current anatomical museums often included pathological sections, connected with sensitive topics such as disease and death, thus leading to greater attention on their preparation and the audience to target. The human remains preserved in these museums according to the indications of the ICOM Code of Ethics for Museums must be considered “culturally sensitive materials”, thus leading to important ethical assessments and greater respect in all phases of the management of a museum, from acquisition, conservation, and preparation. As per ICOM indications, they must be “cared for respectfully” and “presented with

great tact and respect for the feelings of human dignity held by all peoples"[1].

Current Italian anatomical museums are mainly owned by the Universities but often located in old facilities and not always open to the public or scholars, although they preserve important collections of human biological preparations with different preservation techniques, mostly collected between the late eighteenth and mid-twentieth centuries[1,2].

However, recent medical museums have resumed educational and research function, thus leading to new ways of studying the history of medicine and pathology, with a more technological and innovative approach in step with the times. The application of augmented reality (AR), quick response (QR) codes, and other digital technologies within the medical museums proved to be an efficient tool for exhibit displays, but also a way to increase the effectiveness of anatomical and pathological education[2,3,4].

The Pathological Anatomy section of the Morgagni Museum of Human Anatomy at the University of Padua underwent renovation from 2016 to 2018 to enhance the usability of its exhibits for educational and scientific purposes, as well as for visitors without specialized knowledge. The museum was originally founded in the 1860s by Lodovico Brunetti (1813-1899), the first professor of Pathological Anatomy at the University of Padua and currently preserves a collection of over 1300 human pathological preparations, preserved in liquid, dry, or artificially mummified with the tannic technique, invented by Brunetti himself. The collection preserves ancient preparations from the collections of the former Museum of Natural Philosophy, the first science museum in Padua, founded by Antonio Vallisneri senior (1661-1730), professor of Practical Medicine, up to modern cardiovascular pathologies and heart transplants[5,6].

Thus, the Morgagni Museum can be considered among the firsts medical museum in Italy to adopt new technologies, such as QR and AR, for medico-pathological teaching and museum valorization of the preparations.

Materials and methods

Study design

This study adopts a qualitative case-study approach to analyze the renovation and technological enhancement of the Morgagni Museum of Human Anatomy at the University of Padua. The aim is to evaluate how the integration of digital tools within a medical museum context can improve accessibility, educational effectiveness, and ethical engagement with human remains.

The case study focuses on the design, implementation, and use of three main digital interventions: QR, AR, and virtual itineraries. Observational feedback was collected during guided tours, educational activities, and interactions with medical students and general visitors.

Historical background

Paduan medical museology has very ancient roots. Antonio Vallisneri (1661-1730), professor of Medicine in Padua from 1700, collected a collection of natural history, ethnographic, anatomical and anatomopathological preparations which, upon his death, was donated to the University and formed the original nucleus from which several 19th-century university museums derived. In 1808 Francesco Luigi Fanzago (1764-1836), professor of Pathology and Legal Medicine, decided to establish a "pathological cabinet" at his home, to give "new lights to the cultivators of medicine", later transferred to Palazzo Bo in 1822. Thanks to Francesco Cortese (1802-1883), professor of Anatomy, the pathological cabinet not only increased its possessions with preparations executed by the doctor himself, but also saw its premises improved and expanded, which were located near the ancient sixteenth-century anatomical theater[6].

However, it was necessary to wait for the arrival of Lodovico Brunetti in Padua for the transition from cabinet to museum to take place. Brunetti, already an assistant in Vienna to the famous pathologist Karl von Rokitansky (1804-1878), was called to Padua in 1855 to hold the first chair of Pathological Anatomy and immediately set about creating a collection of pathological pieces to be preserved in a museum for educational purposes. At the beginning of the 1860s he founded the Museum of Pathological Anatomy, which continued to be enriched with preparations created by Brunetti himself using a new method called tannization. This system consisted of four phases: blood removal, degreasing of the organ through perfusion in water, tannization through injection of tannic acid through blood vessels, and drying with compressed hot air[5,6].

The current location of the museum took shape from the 1920s, when the former convent of San Mattia where Brunetti had worked was demolished and the building that is still today the headquarters of both the museum and pathological anatomy as research, diagnostic and teaching activities was built[8,9]. Starting from the approval of the consolidated text of laws on higher education (royal decree of August 31, 1933, n.1592), up to the most recent mortuary police regulations (D.P.R. September 10, 1990, n. 285), severe limitations have been defined in the removal of anatomical parts from cadavers, which have in themselves significantly

reduced the possibility of preserving preparations in anatomical museums.

Medical-anatomical museology had its peak in the nineteenth century in the scientific educational field. Later in the twentieth century, they were often used thanks to the popularity of health exhibits in international expositions. However, the change in medical education has led to a shift toward microscopic observations, which are harder to display to the general public and new regulations in the field of postmortem examinations, thus leading to a decline of these museums, often mainly transformed into medical archives and historical biobanks[6,9,10].

Recently, the study of the pathologies preserved in these museums has been deemed important both to understand the evolution of medical practice and to rediscover ancient pathologies, thus leading to an important role in modern teaching and the training of students of pathology and researchers and a new value for understanding Western cultural heritage[6,9].

Therefore, in 2018, the old museum of pathological anatomy of the University of Padua was renovated introducing new modern display cases to allow a more comfortable and safer visit from the harmful agents of some of the

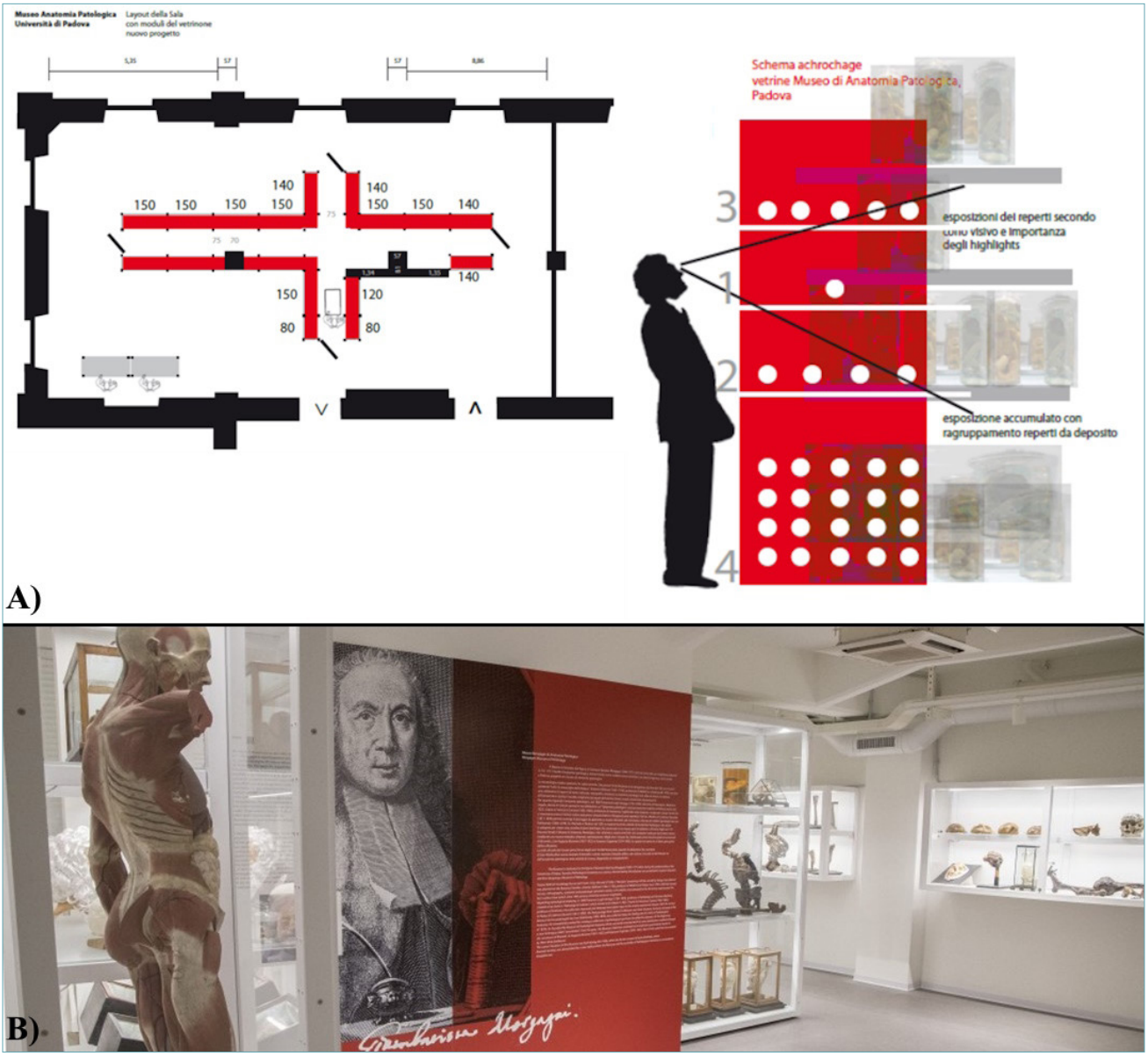

Figure 1. A) The layout of the exhibition; B) Entrance of the section of pathological anatomy of the Morgagni Museum of Human Anatomy.

preservative liquids. It also built a unique state-of-the-art air conditioning system to maintain conditions suitable for the conservation of the preparations. The layout of the exhibition spaces (Fig. 1) highlights the rational organization of visitor pathways, optimized to improve accessibility, enhance the security of the specimens, and ensure the safety of both visitors and staff.

A central element of the project is the longitudinal display case: this structure was designed to provide an optimal view of the samples through a vertically hierarchical arrangement. At the top (zone 1) are the most relevant and representative objects, positioned at eye level; in the upper (zone 3) and middle (zone 2) sections, secondary yet still informative items are displayed; finally, at the bottom (zone 4), less significant or duplicate specimens are grouped functionally, serving as a visible storage area. This setup not only ensures a clear and orderly presentation of the content but also supports safe management of the displays, as the design prevents overcrowding, minimizes the need to move the preparations, and protects both the public and staff during maintenance or visitation. Furthermore, the choice to use transparent glass and white materials has made the museum more welcoming.

The Museum was dedicated to the figure of Giovanni Battista Morgagni (1682-1771) who, during his professorship at the University of Padua, founded Pathological Anatomy as a science, demonstrating that diseases are correlated to organic disorders and first designing a Museum of Pathology, even though never realized. The Museum also preserves the original epistropheus, and facial reconstruction of Morgagni, whose burial was recently identified and confirmed through a combination of archive research, and anthropological and molecular investigations[6,11].

Results

The renovation of the Morgagni Museum of Human Anatomy and the implementation of digital tools resulted in observable improvements in accessibility, organization of the exhibition space, and educational usability, as observed during guided tours and didactic activities.

The renewal of the Morgagni Museum also aimed to bring new interest to the general public on various themes, such as human pathologies and the ancient living conditions of the common population between the late eighteenth and mid-twentieth centuries, often intended only for specialists. It is worth mentioning that in recent years there has also been a spread of many exhibitions of artistic anatomy with plastinated real human bodies, often arranged as modern cabinets of morbid curiosity[12,13]. To convey the scientific value of the Morgagni Museum and to differentiate it from other types of exhibitions, the visit to the Museum is usually a guided tour that allows scientific dialogue between the visitor and the researcher conducting the tour.

New digital methods have also been added to enrich the museum itinerary with different levels of insight, as QR, AR and virtual itineraries as mentioned above. In addition to these methods, traditional written text captions are still available, both on the walls and on paper guides, for greater accessibility and usability of the contents by all types of visitors. Finally, to encourage international inclusiveness, both the visits and the digital and traditional didactics are provided in two languages, Italian and English.

Exhibition redesign and accessibility

The renovation introduced new display cases and an optimized spatial layout designed to improve both visibility and safety. The longitudinal display case system, based on a vertical hierarchy of specimens, facilitated a clearer interpretation of the collection by organizing objects according to their relevance and visibility.

This arrangement reduced visual overcrowding and minimized the need for handling the preparations, thereby improving both conservation conditions and safety for visitors and staff. The use of transparent glass and light-colored materials contributed to a more accessible and less intimidating environment, particularly for non-specialist audiences.

Use of QR codes

Approximately 100 QR codes were implemented across the exhibition, each linked to digital captions hosted on the museum website. These provided bilingual content (Italian and English), images, and additional scientific references (Fig. 2).

Observations during visits indicated that QR codes were frequently used by visitors, particularly by students and younger audiences. The system enabled layered access to information, allowing users to choose between basic and more in-depth content according to their level of interest.

An additional advantage observed was the possibility for visitors to retain access to the material after the visit by saving the linked pages, thus extending engagement beyond the physical museum space.

Use of AR

AR is a technology capable of superimposing multimedia information on what you are watching on any display, enriching sensory experience and actual reality with further contents. For this purpose, a dedicated application was developed to provide immersive ex-

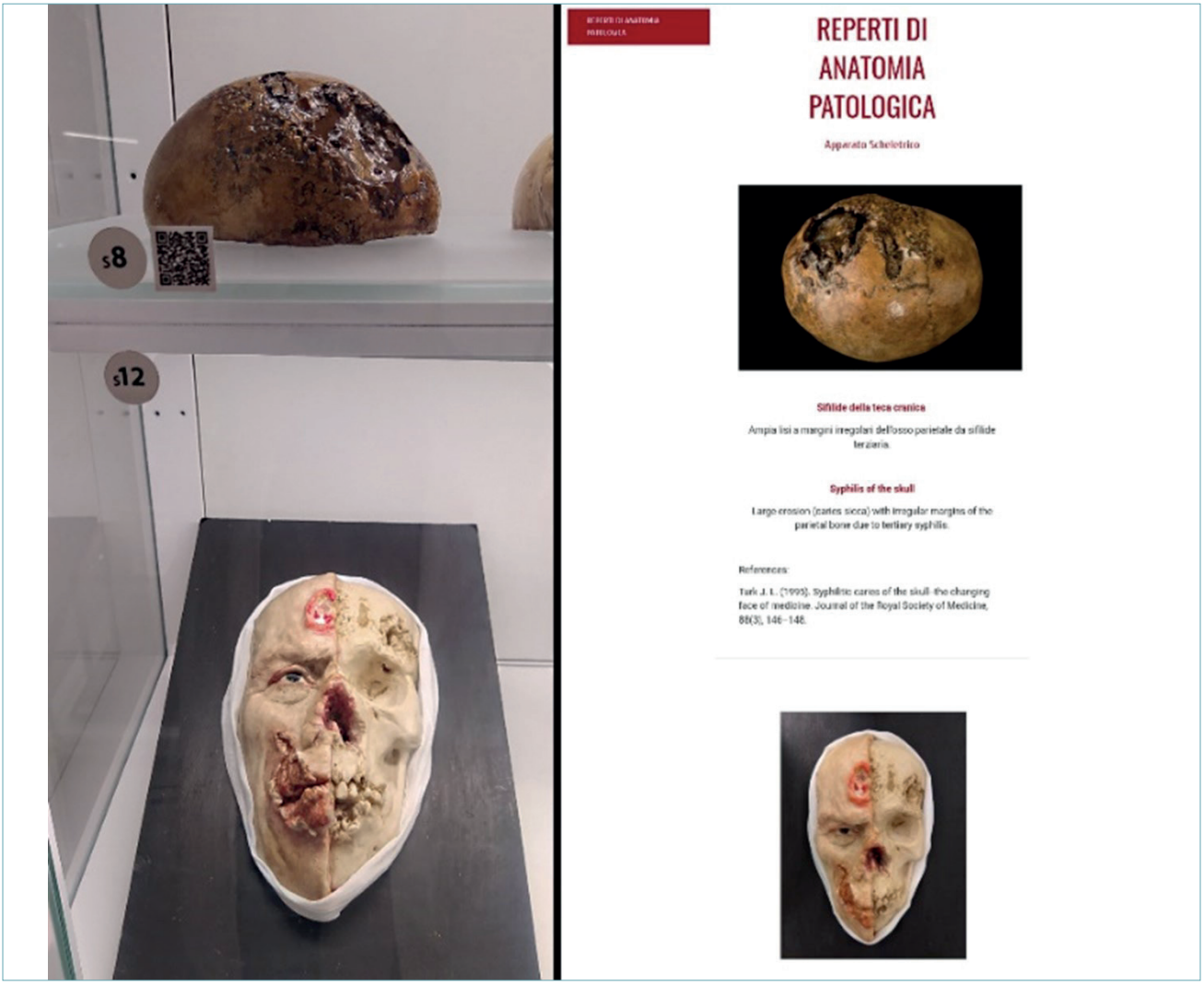

Figure 2. Left: Example of a QR code applied to a showcase in correspondence with the specimen. Right: Corresponding digital caption on the Museum website.

perience in two different ways: AR and Discover (D+). AR has already been applied to several anatomical preparations[14-17], with plans underway to expand its implementation to additional ones.

The AR application enabled visitors to access multimedia content directly through their personal devices or museum-provided tablets. The AR mode replaced traditional fixed screens by allowing video content to be accessed through dedicated panels, while the Discover (D+) function provided real-time interpretive overlays on the specimens. Each hotspot led to dedicated captions about specific details, thus allowing a further deepening of understanding (Fig. 3).

During guided activities, AR tools were associated with increased engagement, particularly among med-

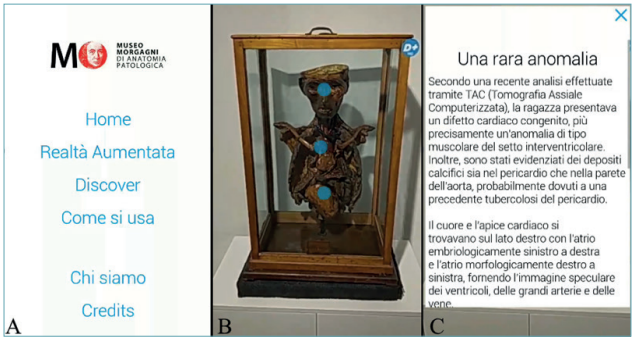

Figure 3. Example of use of the AR app (Italian version): A) Home screen with all selectable options; B) Display screen of hotspots in Discover mode; C) Example of caption obtainable from hotspot clicking.

ical students, who interact more actively with anatomical details when supported by digital overlays and hotspot-based explanations.
The use of AR also has demonstrated practical advantages in terms of sustainability and flexibility, reducing the need for costly and space-consuming hardware installations.

Virtual itineraries and the "diffuse museum" model

The virtual itineraries connected the museum to the broader historical and urban context of Padua, allowing users to explore sites related to the history of medicine both physically and remotely.
This approach expanded the educational scope of the museum beyond its physical boundaries and supported different forms of accessibility, including remote access for users unable to visit in person. The itineraries were also used in educational settings to complement museum visits, particularly in activities aimed at strengthening observational and diagnostic skills.
The project "Virtual itineraries" was created by the company H-Art of Treviso in collaboration between the University Center for Museums and the University Center for Libraries of the University of Padua and financed by the University and the Italian Ministry of Education, University and Research.
The project aimed to offer public routes through the University of Padua heritage, one of the richest complexes of museums and collections of historical and scientific interest in Europe, not always known and easily accessible. A sort of "diffuse museum" in which virtual itineraries are combined with the possibility of planning real visits to various places, thus establishing a better network between the Museums, the University, the city, and the community itself. Furthermore, the project made it possible to improve this network thanks to new levels of accessibility and digital inclusiveness (e.g.: remote visits), mediated participation with the territory, and their didactic and educational purposes.
Within this project, it was created an itinerary dedicated to the places of the history of medicine and its traces in the modern city of Padua, including the Morgagni Museum. The study of medicine has an ancient tradition at the University of Padua, and it has also left many traces in the city and in today's university build-

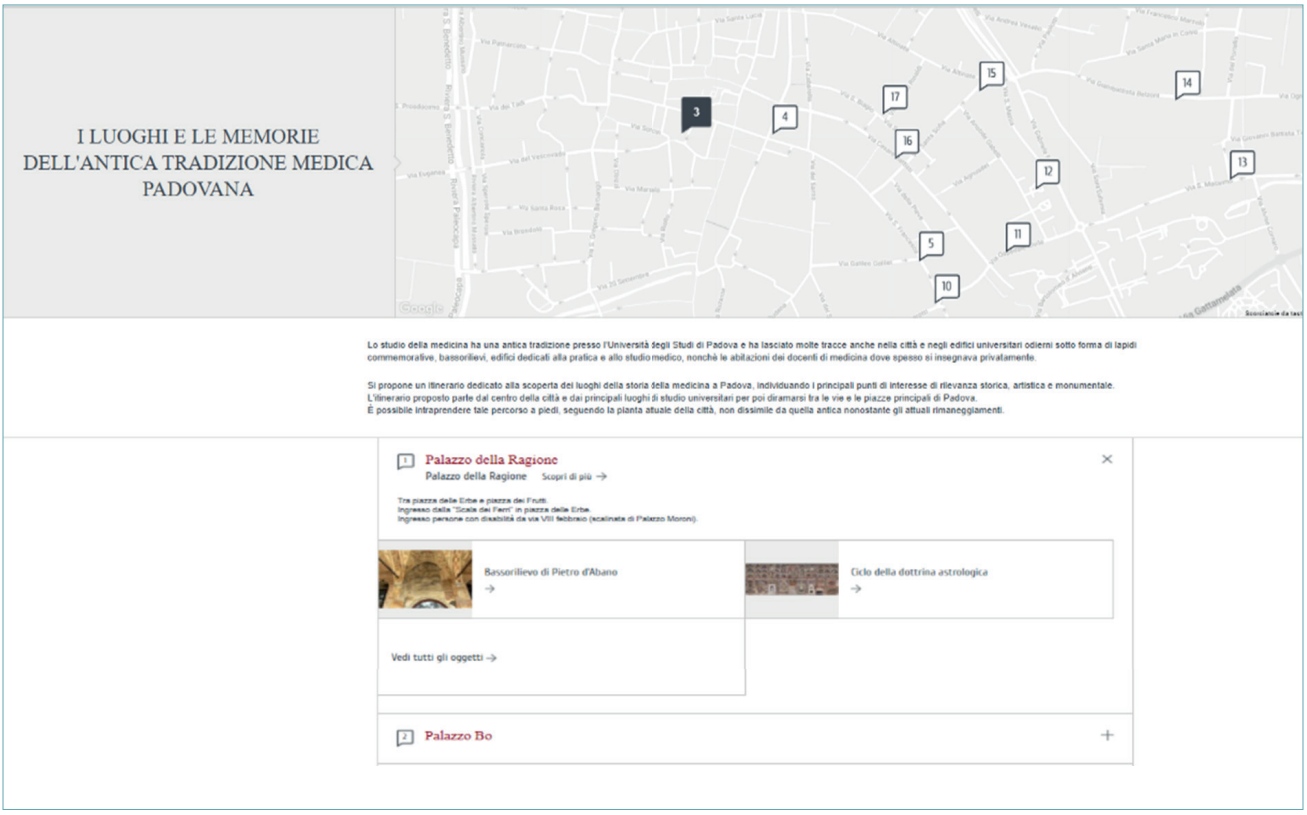

Figure 4. General map of the Virtual Itinerary "Medicine in Padua", with an example of a stage of the route and related points of interest.

ings in the form of commemorative plaques, bas-reliefs, buildings dedicated to medical practice and study, as well as the houses of the ancient professors of medicine where they often taught privately (Fig. 4).
The proposed itinerary starts from the city center, near the historical seat of the University, and then branches off through the main streets and squares of Padua, as the city has not undergone major changes since ancient times. The itinerary is designed to be made on foot as an enrichment of the visit to the Museum, but it can also be enjoyed online for those who cannot walk physically the route.
The use of these virtual itineraries allows greater accessibility and digital inclusiveness, with an in-depth virtual visit to museums or cities even to visitors with motor disabilities or impairments, or just unable to visit the city. The itinerary can be fully enjoyed online, without needing to be in physical locations. The interaction between the Museum, the city, and the community through virtual itinerary has proved useful to develop components of social, experiential, and economic interest, through mediated participation with the local territory.
Following the experience of the first virtual itinerary dedicated to medicine in Padua, a new itinerary for medical students has been created to train their diagnostic skills, comparing paintings and images with anatomical-pathological representations, and then testing their skills in a targeted visit to the museum to recognize them among the exhibited preparations. Improvement of the observational skills and diagnostic abilities of students is indeed considered fundamental in the diagnosis of pathologies, especially nowadays, when physical examination skills are considered[12].

Educational activities and student engagement

Digital tools were integrated into structured educational activities, particularly for medical students. Guided visits were combined with observation-based exercises and digital quizzes designed to reinforce diagnostic reasoning.
Although quantitative assessment was not systematically conducted, qualitative observations indicated that students showed higher levels of attention and participation when interacting with digital tools, especially AR-based features and comparative visual exercises.
The combination of digital and traditional interpretive tools (QR, AR, virtual itineraries, and printed captions) proved effective in accommodating different learning styles and levels of prior knowledge.

Limitations observed during implementation

Several limitations emerged during the implementation of digital tools. Access to online content depends on the availability of a stable internet connection and on visitors' personal devices. In cases of technical issues or limited connectivity, traditional printed captions remained essential.
In addition, some visitors showed reluctance to download the dedicated application, highlighting the importance of providing alternative access through museum devices and maintaining hybrid interpretive strategies.

Discussion

The integration of digital tools within the Morgagni Museum of Human Anatomy has demonstrated how medical museums can evolve into dynamic educational environments while maintaining ethical responsibility toward human remains. The results of this case study suggest that the combination of traditional and digital interpretive strategies can enhance accessibility, engagement, and learning outcomes across diverse audiences.
One of the most significant findings concerns the effectiveness of hybrid interpretive models. Rather than replacing traditional materials, digital tools such as QR, AR, and virtual itineraries functioned as complementary layers of interpretation. This approach allowed visitors to engage with the collection at different levels of depth, accommodating both non-specialist audiences and medical students with specific educational needs. Such findings are consistent with recent studies emphasizing the value of multi-modal learning environments in medical and museum education.
Importantly, digital mediation did not diminish the ethical dimension of exhibiting human remains in a museum context. On the contrary, the integration of contextual information, guided interpretation, and layered digital content appeared to support a more informed and respectful engagement. This is particularly relevant in light of ongoing debates regarding the display of human remains in museums, where concerns about dignity, consent, and cultural sensitivity remain central. The Morgagni Museum case suggests that technology, when embedded within a coherent curatorial framework, can reinforce rather than weaken ethical awareness.
The implementation of AR proved especially effective in enhancing observational and diagnostic skills among medical students. The use of interactive overlays and hotspot-based explanations encouraged active exploration of anatomical and pathological features, aligning with educational approaches that emphasize visual literacy and experiential learning. Similarly, the integration of virtual itineraries extended the educational function of the museum beyond its

physical space, contributing to the development of a "diffuse museum" model that connects collections, urban context, and digital access.

At the same time, this study highlights important practical and methodological limitations. The absence of systematic quantitative data represents a constraint in fully assessing the impact of the implemented technologies. The findings are therefore primarily based on qualitative observations and usage indicators collected during guided activities. Future research could build on this work by incorporating structured evaluation methods, such as user analytics, surveys, or controlled educational assessments.

Additional challenges include technological barriers, such as dependence on internet connectivity and variability in visitors' willingness to use personal devices or download dedicated applications. These factors confirm the importance of maintaining hybrid interpretive strategies in which digital tools complement, rather than replace, traditional resources.

Despite these limitations, the Morgagni Museum case study provides relevant insights for the future of medical museology. It demonstrates that historical anatomical collections can be reinterpreted through digital innovation without compromising their scientific and ethical integrity. More broadly, it supports the view that medical museums can play a renewed role as spaces for interdisciplinary learning, public engagement, and critical reflection on the history and practice of medicine.

In conclusion, this study contributes to the ongoing discussion on the role of digital technologies in museums dealing with culturally sensitive materials. It suggests that carefully designed digital interventions can enhance both accessibility and ethical engagement, offering a sustainable and adaptable model for other institutions facing similar challenges.

Conflicts of interest statement

All authors have no conflict of interest to report.

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Authors' contributions

GM: Conceptualization; Methodology; Formal analysis and investigation; Writing - original draft preparation; Writing - review and editing: Supervision. AZ: Writing - review and editing: Supervision

Ethical consideration

Not applicable.

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