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Prefiguring the reuse of historic hospitals: an approach methodology to design in the digital age

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Abstract

Italy has a relevant stock of historic hospitals, only partially categorized by care type (former psychiatric hospitals, former sanatoriums, etc.). They are not even listed on the UNESCO World Heritage List as individual buildings.

Since Middle Age, hospitals landmarked our cities and gone through ages with scientific progress, and relevant transformations. They never broke the link with the community and often suffered management issues (higher maintenance costs, new regulations, increasingly high-performance requirements, new health protocols) until they were abandoned or changed to new use, thus often losing historic value.

With the current emergency, we must rethink the role historic hospitals can still play, as receptors of new services for the community.

The theme of historic hospitals is within the general reuse of heritage stock, but with particular attention to revitalisation for new health functions or mixed functions.

This paper describes a methodology to explore the potential of such hospitals in terms of value for enhanced health functions to meet a growing demand for local services other than acute hospitals.

Methodology and tools for the adaptability evaluation of historic buildings as new local health services applies to a sample of case studies to explore potential solutions. This can ensure a right balance between financial and functional sustainability and preservation requirements. Emphasis is on identifying a successful mix of applied design solutions and exploitation of heritage value.

Keywords: historic hospitals, reuse, design alternatives, Decision Support System (DSS) tools

1. Introduction

The theme of the reuse of disused historic hospitals in Europe and especially in Italy is still a current issue, given the systematic abandonment of important hospital complexes in different national contexts, due to the impossibility (or lack of will) to experiment and implement new technologies to adapt to the evolution of health care [1].

The uses of many of them, with large available volumes near the historic centres of big towns, were increasingly mixed public and private. Hospitals with historical value and located in smaller cities were not attractive for new uses, but were often abandoned, thus depriving the inhabitants of a cultural, social, and especially health heritage. This valuable heritage includes architecture, works of art, archive materials, libraries, instruments, etc.

The responsibility of a revitalization plan, while preserving the health use, must come along with a wide knowledge promotion. The first step of this would be a reconnaissance nationwide, currently lacking, except for some specific treatment categories, such as former psychiatric hospitals [2] [3].

Throughout history, hospitals have been landmarks of our cities and towns. Evolving building types and their spatial characterization have come along with scientific discoveries, progress in the biomedical field also through major transformations [4]. Most historic hospitals, because of financial difficulties and

maintenance costs (due to new regulations, new performance models and medical protocols), have been abandoned or changed to new functions, often losing its historical and documentary value [5]. The current health emergency offers the opportunity to reconsider the role that historical hospitals can play as key health hubs and receptors of new services linked to urban life and their citizens.

We can deal the topic of historical hospitals within the reuse of the heritage of buildings/ monuments, with particular attention to a new use and remodelling within the network of local health services. The result could be new health functions and protocols highlighted by the emergency and technological innovation in health (e-health, telemedicine) [6].

Characteristics of this heritage stock (never mapped) include data on ownership, availability, building type and volume, age of construction, constraints of protection, state of conservation. Storage of such data is a prerequisite for any reuse plan. Thus, we need an in-depth knowledge of all those data for evaluation of the potential of the heritage stock and the feasibility of revitalization. A lacking identification of such potential could bring to misuse and disposal, as already happened. In this regard we focus on the case of valuable hospitals in Rome, such as the former Carlo Forlanini Hospital (abandoned in 2015 and a case study in this article), San Giacomo Hospital partially in use since 2008 and San Gallicano Hospital, abandoned in 2007 and now with a different use. In addition, there could be several historical sanitary hospitals nationwide, for long time abandoned because too small or severely cut in the national health system budget.

Differently from abandonment, there are also valuable case studies such as Celio Hospital in Rome. Thanks to a military and independent management, it was revitalized through a faster process, which also preserved historic building features and, at the same time, relevant health function (Fig. 1 – Fig. 2). Through the reuse of this heritage stock, in view of sustainability and reduced land use, we can tackle lacking local health services occurred in the Covid-19 emergency with a new pattern of the relationship between hospital and local community.

Indeed, the network of local health services and hospitals did not fit for the management of non-acute patients nor for standard services' performance.

The current contingency can be an opportunity to give back to the community a heritage stock while keeping the original function and exploiting uses within an innovative health care system.

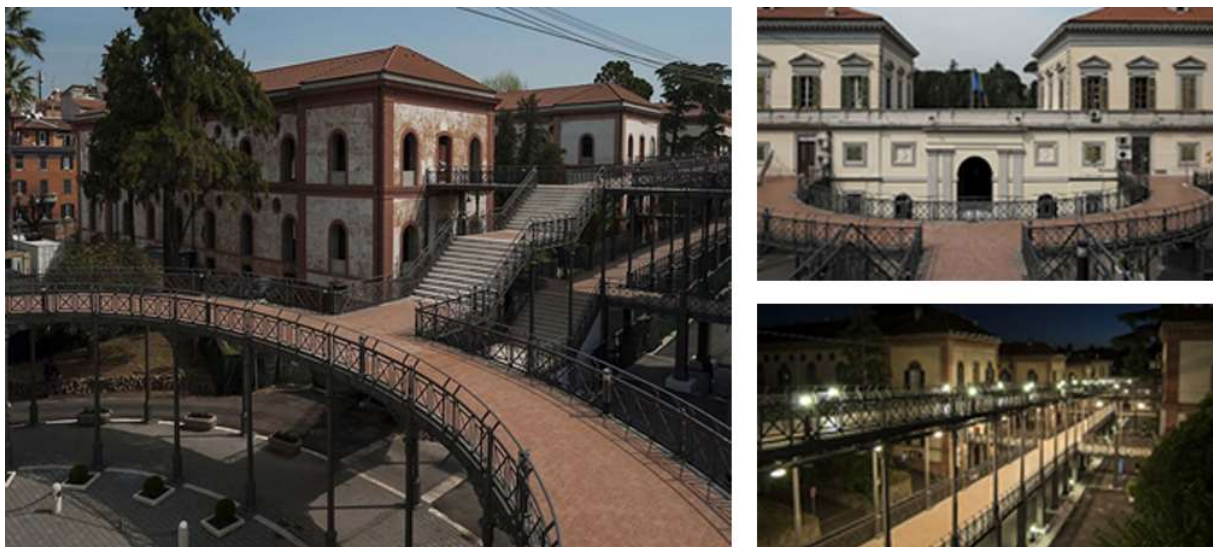


Fig. 1: Military Hospital Celio (Rome). Military Hospital of the Italian Army Health Corps built between 1885 and 1891 by Salvatore Bianchi and Colonel Luigi Durand de la Penne. It consists of 30 pavillions on more than 50.000 square meters, connected through iron walkways, still in excellent condition. Today, the hospital is fully functional and all the revitalizations have fully preserved the original features. In 1987 an extension plan (E. Nespega designer) made new connections of outer heads of pavillions.

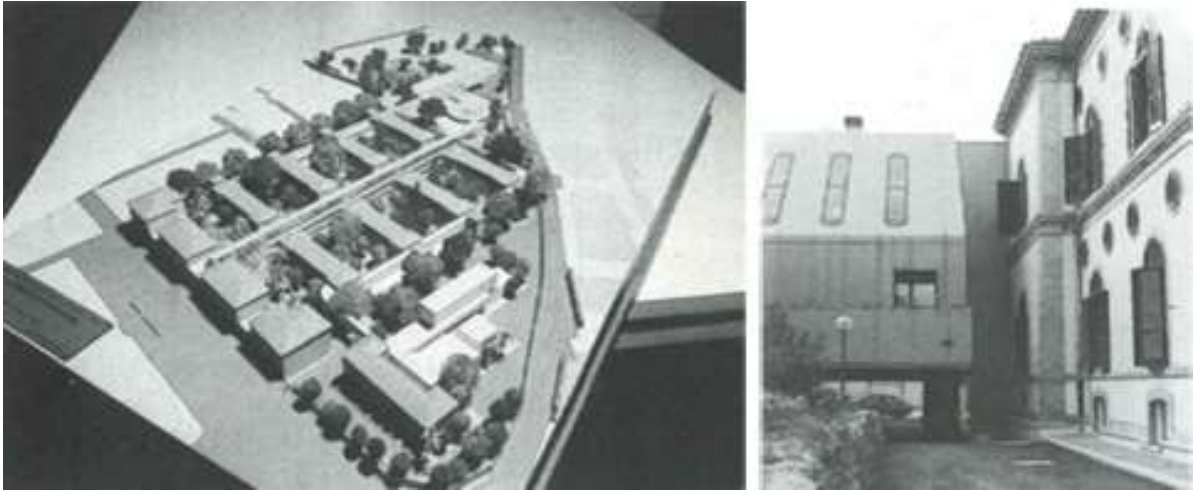


Fig. 2: The new additions clearly highlight a contemporary style and dramatically change the overall hospital re-development, while preserving the historic and monumental features of the whole system. Record sample of revitalized historic hospitals in Italy by keeping health functions, with focus on solutions of adaptability for an application model. These data records are a preparatory tool for mapping of historical hospitals and for a framework of adopted solutions. This is useful for heritage protection, for the quality of health services, and for new technologies (Step 1 of the methodology).

2. Historic hospitals between testimonial value of hospital architecture and new potential in the digital age

The modern hospital building type and functional model starts at the end of 1700 after a long tradition of mainly charitable and welfare model of religious confraternities. Only around two centuries ago the principle of national health systems was established, for the first time in Europe, although limited to frail categories. Construction of the first hospitals in England started to take place gradually together with national health service financed mainly by tax revenue. From that time, models of public health spread in Europe, while in Italy the rights to health were recognized only after the Second World War in the Constitution act [7].

From the oldest court types of the rare hospital complexes in the Renaissance age, through the pavilion model type of the early twentieth century, and finally to plates, towers and mixed plate-towers types, hospital complexes have passed - faster than other buildings - through innovations, different organizational-functional models and especially many management changes due to different budget fluctuations.

A revived interest to architectural quality of care spaces arose in the middle of the twentieth century, as it started from the hospital architecture in the fifteenth and sixteenth centuries (with Buontalenti in the renovation of the hospital of Santa Maria Nuova in Florence, and Filarete in the design of the Maggiore Hospital in Milan). This started the concept of the modern hospital and focuses on the relationship between contemporary design and history of hospital architecture. Also, this highlights even more the testimonial relevance of historic hospitals and how hospital architecture of the past can help build an identity of the European and Italian hospital. Surveying how abandoned historic hospitals were working, some concepts taken from the current health design can emerge: focus on people, search for a dialogue with the city. Such concepts express a culture that goes beyond skilled knowledge and technical aspects.

Thus, an architectural culture appears to interface with the topics of health in society, in the urban landscape of cities and towns. The study of oldest hospitals also provides us with valuable information on how we pursued the concept of patient as a person, a patient-centred vision (no longer only in-patient), the role of a “caring” environment, the care complexity and rapid changes, and finally to how we can quickly cope with the current emergency.

Historic hospitals can still clarify the link between the hospital concept and the evolution of science, techniques, and health policies, specifying the basic concepts of design that give identity to the hospital architecture also beyond a technical context.

The changing functional concept of the hospital through ages is to be found not only in the literature, but also in the samples still present. These, if thoroughly surveyed, can be a resource to supplement the health network, even though with new functions and use which can revive as innovative health services in relationship with local medicine. This should be a priority [8].

Unfortunately many samples of relevant historic hospitals for the aspects above described have suffered a gradual and irreversible financial downsizing since the 1970s, with a consequent abandonment as a result of health policies of increasingly budget cuts in health building loans and at the same time also in the health performance of receptivity of hospitals: number of beds per patient have been increasingly reduced and the situation in recent decades has progressively worsened also due to increasing ageing population. This trend has deeply affected the mechanisms and principles of national health that the government has guaranteed through the provision of services for citizens.

Thus, the organization of spaces, of activities and health equipment has endured in the last decades fast reconfigurations and this trend is even growing due to the fast expansion of services from remote and telemedicine, together with the extension of home assistance that reduces the need for space. On one hand, we can see obsolete hospitals that are no longer able to respond to contemporary needs, on the other hand the phenomenon of the 'miniaturization' of the new hospital concepts is taking place with a view to a new healthcare and digital eHealth. This would put back the historic hospitals because of the lacking flexibility in space and technology can be contrasted with a flexibility of the organizational model that can accommodate limited technological equipment, outpatient and daycentre services while outsourcing all those services that can perform in the digital era.

The pandemic can be the opportunity for a debate on the exploitation of historic hospitals to give back to the community a new model of reuse that does not break with the original function, but rather can enhance it in the shapes and conditions of contemporary society.

If on one hand, technology and spaces of historic or ancient hospitals cannot comply with the requirements of a new contemporary hospital concept, on the other hand such spaces can still revitalize and build new health functions fit with the current and pressing needs of a local medicine. This urgently needs to be deeply renovated if not completely re-established with new methods.

3. Proposal for an approach methodology to reuse design of historic hospitals as a core of the local assistance network. The aid of digital technologies

The proximity of primary care to the citizens, thanks to funds allocated by a decree for economic recovery in 2020 for the reorganization of the local assistance network, was a key role in the management of the new emergency. This would have meant a relevant role of 'filter' of non-acute covid patients to relieve the strong pressure on hospitals. Instead, home health services (USCA) have been enhanced without identification of the network of physical places where to provide primary care.

Thus, this paper starts focusing on how public decision-makers and health directorates of large hospitals and their technical offices tackled critical issues to assess, among available health buildings nationwide and particularly abandoned historical hospitals, those more suitable to switch from the National Health Service to a local medicine model. This allows assessing adaptability through alternative solutions for an effective health reuse as a response to current emergency needs.

We identified, starting from the new health protocols of medical assistance adopted in the local of first aid centres, an approach methodology of reuse design to assess the suitability of historic hospitals and adaptability to new use patterns and new protocols for patient take-care, assistance and the patient's diagnostic-therapeutic pathway.

The methodology takes advantage of a structured system of forecasting tools that empower selection among the possible solutions, of those with the largest number of responses to new space and technology requirements that are consistent with the renewed health care modes.

We refer to digital tools with a long-term forecast model, which goes beyond the works completion and the immediate use. This allows detecting a new life cycle of revitalized historic hospitals through a much larger timeframe. Forecasting tools help define reuse strategies by assessing long-term effects.

We use recent decision support methodologies for health design that can manage input requirements by performing multidimensional analyses. These methodologies and tools are consistent with Generative Architectural Design [9] and Design Optioneering [10].

Generative Design is an iterative man/machine design process, running through parametric design software and visual programming-VPL operating in BIM. This allows designers to quickly screen and optimize several solutions, basing on specific objectives. While traditional "passive" computer use is a mere compilation tool, the generative design establishes a closer link between designer and computer, also exploiting algorithms based on Machine Learning principles. This method generates thousands of solutions for a quick evaluation. The results can be optimised according to needs and resources, even anticipating many evaluation phases at the beginning of the process.

Through this relevant opportunity from the digitalisation of design actions, we illustrate an approach methodology of reuse design below to anticipate and evaluate the adaptability of the historic hospitals to accommodate the transformations resulting from use models of new emergency and management protocols, through a continuous digitalisation process also in health care (e-health, telemedicine, IoT).

The definition of the methodology process and the research use of the specific studies of technological culture of design [11] [12]. This allows to analyse the adaptability of the historic hospitals, through efficiency/efficiency-oriented activities and guidelines for public/private decision-makers in functional

evaluation and alternative solutions for acute hospitals. The purpose is to ensure the compliance of building stock with the new health policies while preserving heritage, by adopting an integrated design [13]. To assess adaptability and transformations of the 'place of care' must start from frail users and staff under pressure and from the study of new use models of space redevelopment. We must consider the link among quality, appropriateness and efficiency of care and the space performance level that shall be increasingly adaptable to establish new organizational and technological requirements coming along with changing care methods and emergencies.

The methodology includes phases and activities:

Bibliographic and on-field survey of revitalized case studies of historic hospitals in Italy and Europe with a new health use; elaboration of information sheets (as shown in Fig. 1 and Fig. 2) with details of adopted solutions, based on effectiveness, heritage protection, quality of health services and environmental, technological and management actions.

Start of a reconnaissance on nationwide of the historic hospitals abandoned or partially in use, potentially suitable for a new health reuse.

The selection includes an analysis of the availability of the stock and the ownership status.

Survey and mapping of relevant case studies for the evaluation of the residual building performance as to technical and economic feasibility of works; graphic rendering through BIM methodologies, SWOT analysis (see Forlanini case study) to identify the first planning strategies and alternative solutions in compliance with new health services.

Survey of operational protocols and adaptation practices conducted during Covid-19 emergency to assume new health scenarios in the former hospitals. Identification of flexible health scenarios along with the pandemic trend can use international (WHO) and national (Ministry of Health) documents, reports, recent directives on health protocols and benchmarks on the management of non-serious Covid19 patients from which to identify predominant activities and impact on buildings (flow changes, management of patients, staff, materials, equipment, etc.). On one hand, the result is the development of a use model that identifies new functions, especially while implemented with digital technologies (telemedicine) and on the other hand it is a set of actions for reconversion, compartmentalization, extension, etc. as linked to the constraint system (structure, installations, etc.).

Definition of environmental and technological requirements for adaptability of historic hospitals. Linking to specific activities of the new local health services, we can identify basic requirements of single rooms of the organisational model. The result is a structured system of environmental and technological requirements able to highlight the minimal admissible threshold with the criteria for assessing alternative design solutions generated in the next methodology steps.

First expeditious evaluation of the suitability to transformation of historic hospitals basing on the overall building flexibility and single environmental units. We obtain information to assess adaptability potential through a fast evaluation tool in the mode of automated checklists. These are based on observation/evaluation criteria of technological and spatial flexibility coming from the literature and adapted to the specific case. The result is a system of constraints also of historic-architectural nature, necessary to determine the adaptability level.

Generative Design application and elaboration of the prefiguration/generation algorithm with evaluation of alternative solutions, through the translation of requirements and design constraints into logical-mathematical processes. Using visual programming software (e.g. Autodesk Dynamo) in the BIM environment and Generative Design methodologies, we can transform the information on the use model, on the requirements system and on the constraints system into requirements to be met, by defining the action range of the "program" variables. This allows to start a prefiguration/ generation of design solutions for reconfiguration of a theoretical model of historic hospital to be renovated (algorithm generator). This provides a 'cyclical' replication in search of the most suitable configuration for specific uses in compliance with constraints. The result is the generation of n compliant solutions to start the evaluation (evaluator algorithm).

Classification of pre-established/generated and assessed adaptability solutions suitable for identifying the necessary actions. The application of *Design Optioneering* methodologies (e.g. Autodesk Project Refinery Beta) allows a multi-objective evaluation of n prefigured solutions to check their compliance with the initial objectives. The first three design solutions identify the actions and a rough cost estimation. The approach methodology to the reuse design is being validated/implemented through the application of some case studies of historic hospitals that can supplement the network of local services.

4. Preliminary analysis on the effectiveness of the reuse methodology: the case study of Forlanini Hospital in Rome

Analysis of this case study highlights the opportunity of an exploitation of the large abandoned historic hospital complex. We check suitability of reuse, transformation and adaptation to new required health and social functions of the local health care district. We can evaluate this based on several structural constraints for the current state of conservation of the hospital, which appears severely damaged after abandonment.

We carried out an in-depth study through applying the first phases and activities of the described methodology. Forlanini Hospital in Rome has recently arisen a political debate of great impact that finally ended up with abandonment and inaccessibility. The hospital complex was built between 1930 and 1934 by the "Ufficio Costruzioni Sanatoriali" (I.N.F.P.S) on design of Ugo Giovannozzi and Giulio Marcovigi Poggi (who was in charge of the Works Direction). The original use was Antitubercular Sanatorium, thus designers chose a mixed morphology between the hospital pavilions type, as a relevant tradition of Hospital construction, and the polyblock type with emphasis on connection areas (Fig. 3).

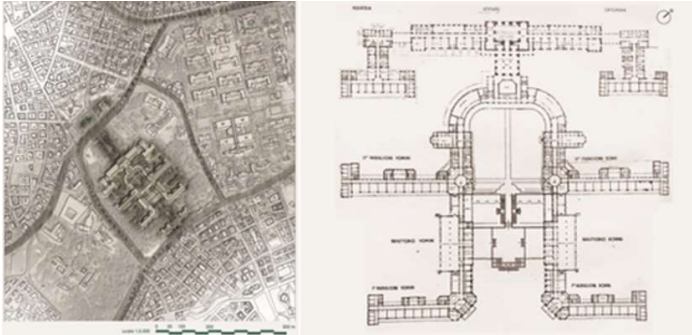


Fig. 3: General plan of Forlanini hospital complex in Rome and floorplan of the first level.

The construction site set-up phase (Fig. 4) was a difficult but well-organized plan, so that the whole complex was completed in only four years.



Fig 4: Construction steps of the hospital complex.

Compared to other health facilities of that age with the same functions, Forlanini Hospital showed features of greater functional and architectural modernity; adopted solutions provided for an optimal mix of different operating models.

For the monumental side, a T-shaped building is used. Instead the U-shaped exedra was the main circulation area. Finally, the linear pavilions are arranged to ensure the best exposure on the elevations (Fig. 5).

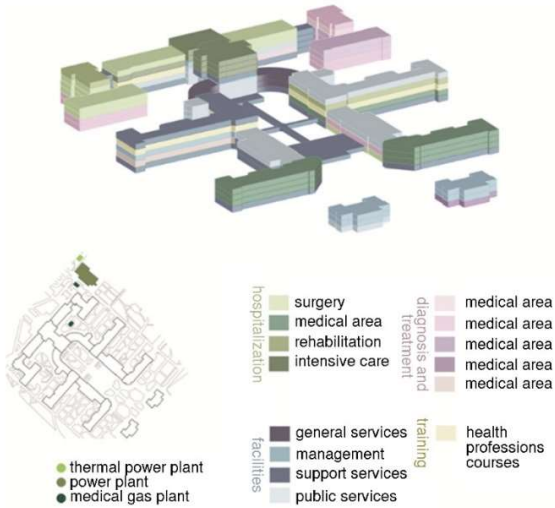


Fig. 5: Reconstruction of the functional mock-up of Forlanini hospital of Rome.

In the 70s the complex was converted into a general hospital under the National Health System management (no longer by INPS – Nation Social Security Agency) with a specialization in respiratory illnesses.

In 1994, the Hospital company of Rome was established from the merger of Forlanini, Spallanzani and San Camillo hospitals. After two years, Spallanzani became an independent branch of research and a new San Camillo-Forlanini Hospital entity was established.

During the regional health system programs of the 2000s, the complex had to undergo several management problems for its complexity and size with increasingly maintenance costs.

In 2006, with the resolution 2145 of 27 October, the company closes Forlanini Hospital and shift activities to San Camillo Hospital (Fig. 6).

In 2008 a final closure was established; in 2010 Prof. Martelli (Special Commissioner of the Hospital company) submitted a renovation plan. In the next years, renovation plans and guidelines have come along without any health/care function.

Today, the complex is totally abandoned and there is no plans for revitalization.



Fig. 6: Phases of abandonment of Forlanini hospital of Rome and areas still in use (green).

Within this methodology, the analysis phase led to highlight the choices about a potential reuse. Considerations from different viewpoints include:

- need to *analyse the motivations that brought to the progressive obsolescence* of the hospital, mostly due to no maintenance.
- evaluation of *strong points of these large hospitals*, which in some cases were a largely spread functional type model reference (the pavilion was a long-lasting hospital building type over 2 centuries).
- many of these hospitals have occupied *large urban spaces* that have strongly affected organization and building expansion in the neighbourhood.
- in the last decades, technological progress has affected many sectors, including construction and technological systems. This would allow to face with more awareness feasibility of a spatial and technological remodelling of the whole complex.

Through this approach methodology for reuse design, we could conduct a preliminary *analysis of the potential*, starting from the analysis of many factors affecting the historic "hospital system" and the context (location, construction history, new user requirements, etc.).

Such factors are:

- the original *welfare function*, which affected location and size;
- the *urban role* of the hospital from the beginning as a functional model in the city; large outdoor areas of hospitals (where present) can be returned to the city for a wider vision of revitalization of the surrounding urban landscape: this can be a large urban enclosure, an extra-urban facility, or a perfectly blended piece into the stratified urban landscape.
- the monumentality of *architectural image* as sign of city identity and memory of the city evolution; this image is strongly linked to the morphological model of the hospital: pavilions and multi-block types.

By transferring one of the most common decision-making tools of this methodology from the planning process, we can proceed to a SWOT analysis that highlights the potential and critical issues of a reuse action (Fig. 7).

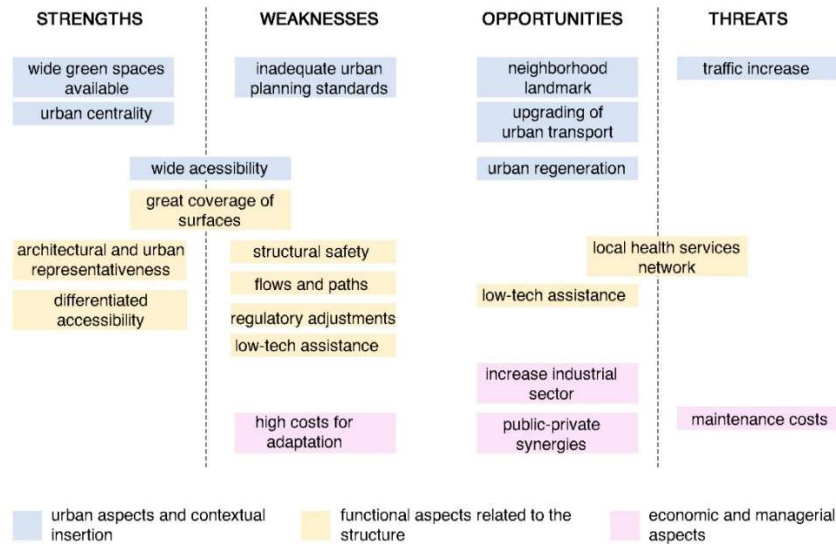


Fig. 7: This scheme shows the analysis areas for assessing the decision opportunities. As all methodological tools, this must always be adjusted with the reference context. Based on conducted methodology with particular attention to the analysis of building consistency and health and social welfare needs of the surveyed urban area, we can prefigure a first assumption to accommodate different functions: the area of local health services needs further remodeling for the current emergency demand; the area of neighbourhood services open to the public (including a library and an heritage museum of the historic hospital; areas for research and testing, inclusive of areas for university education and post-university training (in the medical sector).

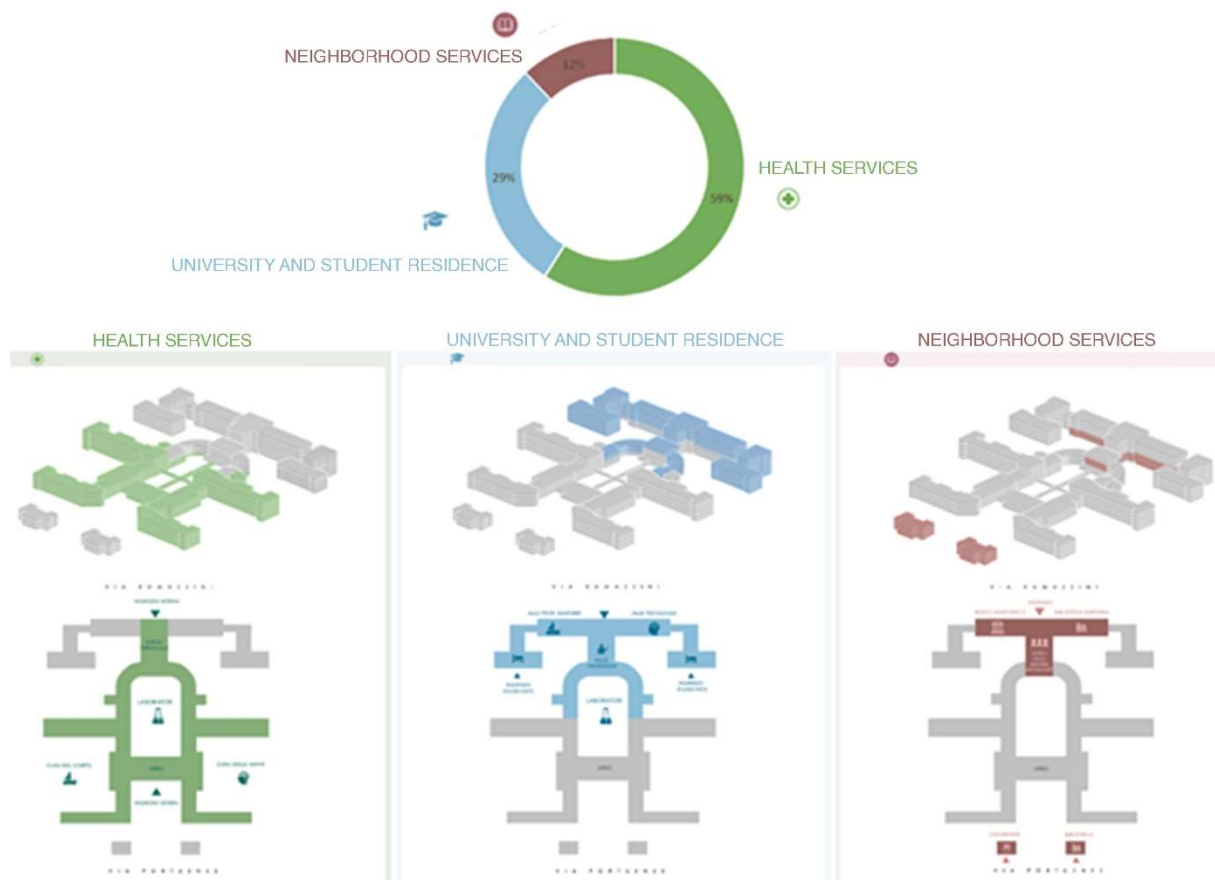


Fig. 8: First reuse and assumptions and functional remodelling of the historic hospital. The main function is local health services, with additional functions to enhance facilities and revitalize the context.

From analyses carried out, the reorganisation plan includes 3 macro-uses:

1) **Health:** a neighbourhood health care service of local medicine that can meet a large demand from the community; also, such local health services can reduce the workload of large high-tech hospitals in the city. Within this proposal 60-65% of the total area is on use for low-cost health activities such as:

- rehabilitation services (cardiological, neurological, post-covid, etc.) open to the public, while connected to low-intensity care areas and and/or daycentres that should be accommodated on the upper floors;
- specialist polyclinics, vaccination and/or prevention centre, which, during the current emergency, could help control and reduce the pandemic.
- multispecialist diagnostic centre (also private) (Fig. 9 on the left).

2) **Education/Training:** this takes about 30% of rooms, due to unsuitable health reuse. In addition, the presence of several health trainees and interns from the close hospital complexes of S.Camillo and Spallanzani gives the opportunity to implement proper education services for different users (classrooms, department rooms, libraries, laboratories, etc.). Areas for analysis and research laboratories should be also considered as a mixed use between health and training activities (Fig. 9 on the right).

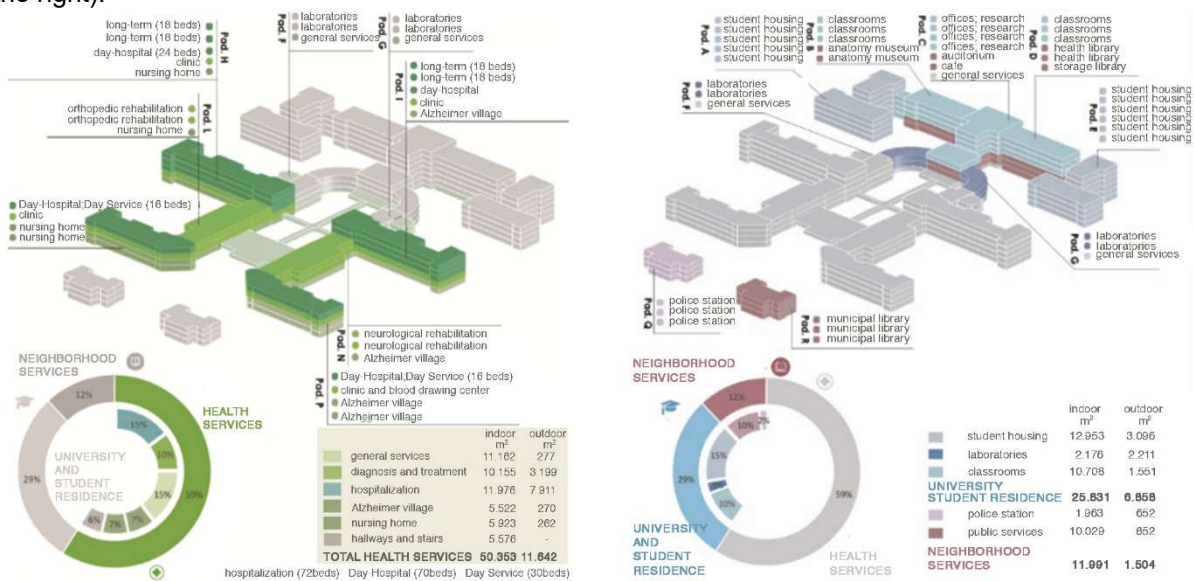


Fig. 9: Left: Functional organization of the complex areas revitalized for health activities. Right: Functional organization of the complex areas of university education and training for different medical and scientific research staff.

3) **Public use:** about 10-15% of the complex is large green areas of value that could be used as open services to the public (Fig. 10): a museum of the hospital history (already partly existing) with a conference centre and neighbourhood library.



Fig. 10: Reorganization of green areas also for therapy services.

The three macro-uses are well combinable and would be a valuable opening to the community. For a prospective health reuse there are still the rooms in the basement, which were previously used as automated freight of medical supply. The reuse concept of this case study is currently under evaluation through the Generative Design tools to determine further design alternatives for the next effectiveness evaluation

5. Conclusions

From methodology and test applied to Forlanini Hospital in Rome, we identify and evaluate design solutions adapting to new use. The key is to run programming tools which screen all potential solutions and select the best match of the largest number of responses to the new needs of society.

Thus, future development shall increasingly adopt prefiguring power of current digital technologies [14] to help cope with our fast changing social, economic, environmental, and political age. These factors continuously affect the final objectives for identifying reuse decisions. Digital design tools shall support managers of these abandoned hospitals and enhance the impact prediction of reuse layouts in terms of savings for management and maintenance costs of revitalization, but also for better health conditions of the community, which is a fundamental need.

The approach methodology to reuse design shall extensively use predictive tools in different hospital use scenarios with different construction techniques, types, and historic contexts. This is a prompt response to different user models.

Generative Design anticipates for each need the evaluations for specific historic hospitals and specific factors such as the budget of involved parties, the type and number of buildings and the final objective of the reuse plan. Relevantly, the result is an added "value" (cultural, social, economic, or personal) to this heritage. In this way, through timescale optimization, decision-makers shall be able to anticipate the most efficient scenarios, not in a single viewpoint, but in a balanced matrix of requirements.

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