NEXT GENERATION HOSPITAL: strategies and tool for the hospital of the future[1]

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ABSTRACT

This study originates from a research initiative led by the Joint Research Partnership Healthcare Infrastructures (JRP HI), established in 2022 by the Department of Architecture, Built Environment and Construction Engineering (DABC) of the Politecnico di Milano in collaboration with Fondazione Politecnico. The objective is to define strategic frameworks and practical tools for designing the hospitals of the future—intelligent, resilient, sustainable, and patient-centered. The research applied a multi-method approach including literature reviews, focus groups, case studies, and benchmarking analyses, culminating in the development of two core outputs: the Functional Model and the Performance Model. These models provide meta-design guidelines and measurable KPIs for sustainability, risk management, and digital innovation. The study also introduced a national Cost Observatory to analyze investment strategies in hospital infrastructure. The results highlight the need for parametric spatial planning, measurable KPIs, and multidisciplinary collaboration. Contributions include evidence-based strategies to address demographic shifts, climate challenges, and digital transformation, forming the foundation for the Next Generation Hospital®. This paper offers a roadmap for transitioning healthcare infrastructure towards high-efficiency, high-quality, and adaptable models, with the potential to influence public health policy, institutional planning, and design regulation at national and international levels.

***Keywords**: Next Generation Hospital®; Hospital design; Meta-design strategies; Research Partnership.*

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1 INTRODUCTION

In 2022, the Department of Architecture, Construction Engineering and Built Environment (DABC) of the Politecnico di Milano, together with the Politecnico di Milano Foundation, established the Joint Research Partnership Healthcare Infrastructures (JRP HI). The JRP HI is a research platform aimed at institutions and companies operating in the healthcare sector. Its goal is to rethink the concept of the hospital, transforming it into intelligent, resilient and patient-centered infrastructure. The JRP HI addresses key issues such as ageing population, declining birth rates and evolving healthcare models, proposing innovative solutions ranging from healthcare organization to the use of advanced technologies. This initiative redesigns hospital system paradigms and represents a model of virtuous participation between academia, industry, and institutions. Thanks to the involvement of the ABC Department at the Politecnico di Milano and the Design & Health Lab, new design, technological and organizational strategies are being tested as part of a broader vision for the transition of healthcare towards the Next Generation Hospital® model.

Since its establishment, the JRP HI has attracted numerous partners, enabling them to develop different research perspectives through working groups, observatories, thematic focus groups, steering committee meetings, regulatory working groups and annual plenary meetings. To date, over 600 stakeholders have participated in these activities. The partnership now includes over 50 organizations, including architecture and engineering firms, construction companies, manufacturers or suppliers of materials, resources or devices, facilities management companies, specialist consulting firms, Energy Service Companies (ESCOs) and financial institutions, as well as various hospitals throughout the country.

Figure 1 – Next Generation Hospital



Source: Design & Health Lab, JRP HI Annual Report 2024

This initiative has also contributed to make the Politecnico di Milano as a Collaborating Center of the World Health Organization in "Design & Health: Healthcare Infrastructures Planning, Design, and Evaluation" for the period 2024 to 2028, with the aim of supporting the European region in implementing healthcare infrastructure requirements.

2 THE NEXT GENERATION HOSPITAL

The JRP Healthcare Infrastructures research platform's objectives for the first three-year period (2022-2024) focused on developing an innovative approach to designing, constructing and managing hospital infrastructures in the future. This approach would be shared among the various players in the supply chain and validated by the relevant institutional actors. The focus was on defining the 'Next Generation Hospital', which is based on the principles of functionality, sustainability, digital innovation and user-centeredness. The strategic objectives included defining meta-design strategies, developing measurable performance requirements (KPIs), creating a standardized terminology glossary (UNI standard) and developing practical tools for designing and managing resilient, technologically advanced healthcare infrastructures. The program also aimed to establish a collaborative network among key stakeholders in the sector by facilitating the sharing of knowledge through literature reviews, interviews and focus groups. Objectives also included implementing and integrating the most advanced sustainability, well-being, and digitization strategies to improve the efficiency of existing infrastructure and support the transition to user-centeredness healthcare models. This approach aims to integrate hospitals into a changing ecosystem and enable them to respond to contemporary social, technological and economic challenges, providing a clear path towards future healthcare. At the end of each year a report on the results achieved and the strategies implemented is published, reserved for members of the research platform.

2.1 The research

During the initial stages of research, the JRP HI platform began surveying the needs framework, the macro-trends affecting the transition of healthcare, with reference to the challenges of aging, rapid technological transformations, and an integrated approach from a One Health perspective. As a result, three main characteristics were identified for modeling new development scenarios related to healthcare infrastructure: the Rethinking of the Post-Pandemic Hospital based on the Decalogue proposed by the ABC Department during COVID-19, which listed the principles around which hospital design revolves in light of the challenges that the recent pandemic has highlighted on a global scale; the Territorial Network in support of the Healthcare of the Future and the need for a safe, sustainable, and technological hospital.

The research activities then focused on the objective of "grounding" the guidelines and strategies gathered during the first exploratory phase of the JRP HI platform. In this second phase, the foundations were laid for updating and modernizing the main references in the field of hospital design. The output was a set of Next Generation Hospital meta-design guidelines structured into two research products:

- The Functional Model, which contains guidelines relating to the composition of

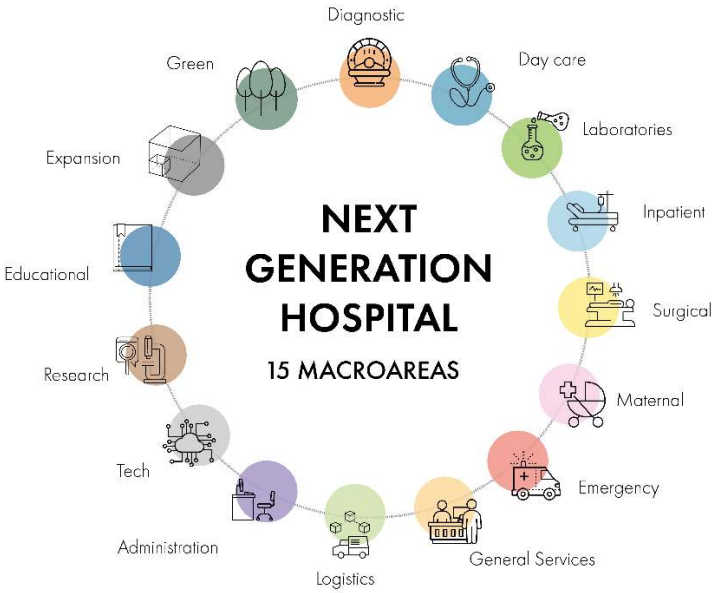
hospital infrastructure in functional areas and their spatial relationships. The results obtained were the definition of 15 macro-areas, composed of homogeneous functional components that can be aggregated according to their technological and structural complexity, type, and level of patient criticality.

- The Performance Model, which is a collection of requirements that must be met to ensure that the hospital infrastructure delivers specific performance levels and to achieve, in concrete terms, a future-proof hospital model. The requirements are organized in a checklist based on the guidelines of the World Health Organization's Technical Brief "Hospitals of the Future" for newly built hospital infrastructure. The design support framework consists of several areas, such as Sustainability, Risk Management, and Digital Innovation. Each area includes investigation criteria to verify the presence of a given characteristic or the exceeding of a threshold value.

The research continued the activities for the Functional Model, Performance Model (sustainability, risk management, and digitization), and the Observatory on Construction and Management Costs of Hospital Infrastructure was added.

The macro-areas of the Functional Model were analyzed from a parametric point of view to obtain a percentage dimensioning, derived from a critical analysis of the latest generation of case studies that have been completed and/or are in progress. The study made it possible to obtain percentage estimates for the different macro-areas. The benchmarking of percentages makes it possible to predict the minimum space required for the needs of the various areas, helping to improve internal flows and operational proximity between related areas. This allows for effective technical and scientific support in the decision-making and strategic planning processes of new-generation hospital organizations. The configuration of spaces must be based on a balance between the different functional areas, with a clear focus on operational needs and user comfort.

Figure 2 – Macroareas of the Next Generation Hospital



Source: Design & Health Lab, JRP HI Annual Report 2024

The Performance Model, consisting of KPIs for Sustainability, Risk Management, and Digitization, describes the requirements that must be met to ensure specific performance levels for hospital infrastructure and to achieve, in concrete terms, a future-proof hospital model that supports institutions, industrial players, and the entire healthcare infrastructure supply chain to contemporary, high-quality standards and ensure efficiency throughout the infrastructure's useful life. The requirements are organized based on the composition of the performance model and include measurable performance criteria (KPIs), a snapshot of the state of the art, and possible meta-project strategies.

- Sustainability: the results show that the Next Generation Hospital must be a highly sustainable hospital from an environmental point of view, optimizing its consumption in line with the reference values identified in the literature, producing renewable energy on site, especially given the sharp increase in energy costs, consuming mainly renewable energy as it is a constantly active facility, and being efficient in the management of its resources and in the principles of environmental sustainability in the location and master plan phases. The Next Generation Hospital must be a highly energy-efficient facility that aims to minimize its negative environmental impact.

Figure 3 – Sustainability strategies

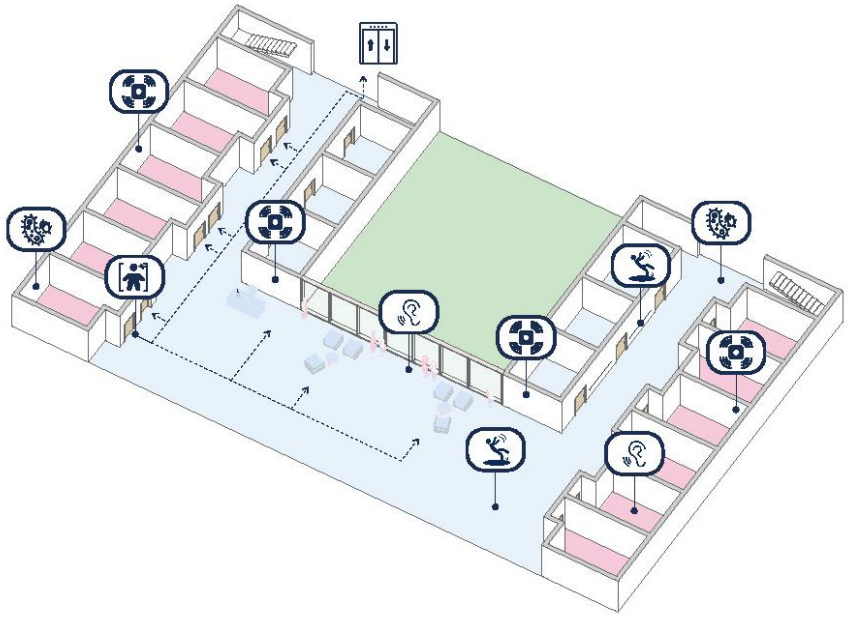


Source: Design & Health Lab, JRP HI Annual Report 2024

- Risk Management: The result was the definition of some possible design strategies for the Next Generation Hospital, derived from studies that highlighted multiple shortcomings in the design aspects aimed at mitigating risk in some of the facilities analyzed. These design strategies were divided into five criteria: improving indoor air quality, mitigating healthcare-associated infections, safety, mitigating the risk of falls, and emergency risks.
- Digitalization: the strategies obtained are the adoption of advanced digital tools that aim to improve operational efficiency by optimizing resources and decision-making processes. This translates into superior clinical outcomes, thanks to personalized diagnoses and treatments, supported by artificial

intelligence and big data systems. At the same time, strengthening security and control mechanisms ensures a protected environment for patients and operators, reducing errors and risks.

Figure 4 – Risk management and Digital strategies



Source: Design & Health Lab, JRP HI Annual Report 2024

The Cost Observatory aims to support the work of the research platform, particularly in defining the meta-project for the Next Generation Hospital. The observatory aims to raise awareness among institutions, industry operators, and citizens about the importance of considering healthcare infrastructure costs as a strategic public health investment. In this sense, it aims to limit the tendency to underestimate the resources allocated for the construction of these strategic works, which limits the quality of projects, exacerbating the gap between the national hospital building stock and that of the main European countries. The analyses carried out have highlighted the gap between Italian and European construction costs, the parametric construction values relating to recent tenders for new hospitals have been analyzed, and average parametric values for the management of healthcare facilities have been identified. This observatory was created to fill an important gap in the planning and management of healthcare infrastructure in Italy. This tool aims to systematically monitor, collect, and analyze data on the construction, maintenance, and management costs of hospitals, providing a clear and up-to-date view of the entire life cycle of healthcare infrastructure.

The possible meta-design strategies suggest the main trends for the design of future-oriented healthcare infrastructure, based on the latest scientific literature, international best practices and, above all, thanks to the activities of the third year, on an in-depth analysis of a sample of Italian hospitals, which has made it possible to interpret the specific needs and state of the art on which to base the evolutionary strategies described.

2.2 The future

The JRP HI's program of activities for the second three-year research period aims to address three major global trends in particular:

- Demographic changes, which are leading to changes in the epidemiological profiles of the population and, consequently, to a growing demand for health and social care services in terms of hospital and local infrastructure, with reference to new models of primary care, long-term care, and senior living. Currently, people over 65 represent 24% of the Italian population, but this figure is expected to reach 34% by 2050. This transition will increase the numbers and complexity that the infrastructure must manage, addressing issues of comorbidity, frailty, and social inclusion. Furthermore, as the European Commission points out in its recent report on the state of health systems, the aging population has an impact on healthcare not only by increasing patient needs but also by reducing the workforce currently available in the healthcare sector.
- Environmental and climate change, which requires facilities equipped with sophisticated building management systems that optimize energy use, as well as climate mitigation features such as green roofs, high-performance windows, and super-efficient building envelopes. Hospital waste will likely come under scrutiny. Support for digital hospitals will spread globally. Considering these transformations, hospital projects should reduce long-term operating costs rather than focus on one-off investments, considering factors such as environmental impact and long-term sustainability.
- Technological transformations and artificial intelligence, which are becoming a strategic issue in all sectors, and recent reports show that more than two-thirds of large companies intend to increase their investment in this technology over the next three years. The major challenges posed by digital technology, from Big Data to the Internet of Things to the practical and ethical implications of using Artificial Intelligence models, can only be addressed through a multidisciplinary approach capable of capturing innovation and transferring it to architectural design as a privileged place for constant dialogue between research, professionals, and institutions.

In light of these three main drivers, the activities of the research platform for the next three years (2025-2027) will focus on expanding the meta-design strategies identified to date, with a possible concentration on different functional areas, drafting meta-design guidelines for the various macro-areas of the hospital system, including analysis and definition of specific criteria for each area, and an expansion of issues related to costs and financing.

3 CONCLUSIONS

The JRP HI research group is constantly growing and represents the healthcare infrastructure sector's commitment to innovation and collaboration across multiple disciplines and stakeholders. In a context that is often hyper-specialised, the project

stands out for its ability to bring together institutional bodies, industrial partners and research organizations on an open platform oriented towards the future.

Designing innovative healthcare infrastructure requires evidence and practice-based approach to promote advanced, inclusive and sustainable care spaces through the synergy of research, experimentation and technology transfer. The results of the first three years of research confirm the effectiveness of this model and reinforce the need to continue in this direction.

The results obtained and the roadmap for the next three years confirm the strategic importance of this issue for the country's healthcare system. It is hoped, therefore, that these innovations will be rapidly adopted at cultural, operational and regulatory levels, resulting in new accreditation requirements for the future planning, implementation and management of healthcare infrastructure.

Figure 5 – Possible future scenario for the Next Generation Hospital



Source: Design & Health Lab, JRP HI Annual Report 2024

REFERENCES

Capolongo S, Edilizia ospedaliera. Approcci metodologici e progettuali, Editore: HOEPLI, Anno edizione: 2006, ISBN: 9788820334963

Capolongo S. Rethinking hospital architecture. AREA, Settembre/Ottobre 2023, 10: 4 - 11 ISSN: 0394-0055.

Capolongo S, Brambilla A, Surace A, Fontana M, De Mezza C. Il futuro delle architetture ospedaliere. MODULO, Giugno 2023, 443: 38-41

Brambilla A, Rebecchi A, Capolongo S. Evidence Based Hospital Design. A literature review of the recent publications about the EBD impact of built environment on hospital occupants' and organizational outcomes, Annali di Igiene, 2019,31: 165-180

World Health Organization. Hospitals of the future: a technical brief on re-thinking the architecture of hospitals. Copenhagen: WHO Regional Office for Europe; 2023. Licence: CC BY-NC-SA 3.0 IGO.

Capolongo S, Dolcini M, Brambilla A. Building Health: The Evolution of Healthcare Infrastructures Through the Lens of Human Evolution and Social Changes in Lara-Hernandez JA, Melis A, Boarin P, Besen P. "The Dusk of Design. Exploring Multidisciplinary Approaches and Evolutionary Biology in Architecture", p.205-218. Springer Nature Switzerland AG 2025. ISBN: 978-3-031-76866-8

Design & Health Lab, JRP HI Annual Report 2024, 2025.