



Editorial

Smart hospital: The future of healthcare

1. The evolving healthcare system

For some time now, healthcare has been shifting from treating diseases in hospitals to managing health with the involvement of patients and healthy citizens, while at the same time emphasizing the need for improved quality of care and value creation [1,2].

To much extent this transition is enabled but mature technology with successful implementations in the real-world setting. For example, a recent publication reviewed data from more than 2000 studies evaluating telemedicine implementations in the 53 countries of the WHO European region [3]. Pooled results show a clear benefit of telemedicine interventions to reduce time to respond, and to reduce unnecessary visits to the hospitals and unnecessary referrals to specialists.

Streamlining patient empowerment, using technology amongst else, is also driving the healthcare evolution, thus leading to increasingly more informed patients and individuals who are actively engaged with their health and wellbeing [4].

Another key facilitator is the wide adoption of technology for personal and continuous monitoring of numerous health and disease related parameters, in the hospital, on the go and at the point of care [5]. This wealth of health data, collected for the first time in significantly large amounts, can in turn enable meaningful analytics to support personalized risk prediction, timely and correct differential diagnosis, precision therapy, and prognosis and delivery of the right preventive intervention at the opportune moment for each individual.

Health care evolution is further driven by the realization of a global underinvestment in health personnel. The ensuing crucial shortage of healthcare workforce which is recorded worldwide over stresses healthcare systems, rendering access to expert personnel and treatment a challenge [6]. Given the potential of current technology and the pressing healthcare problems, WHO has identified the integration of new technologies in healthcare as one of the most pressing challenges of the 21st century [7].

Although it may be difficult to predict what future healthcare may look like, there is little doubt that the concept of today's hospital will be revolutionized by current developments in information technology, entering the era of the smart hospital.

2. The smart hospital concept

Although the term appears in scientific literature around the late 80's [8], the concept of a smart hospital emerges systematically only during the last 20 years [9].

Spawned by administrative needs and assets management, a smart hospital was initially regarded as an organization with the mindset and

procedures in place to reduce costs and accidents related to healthcare service provision, mainly via better assets management. At this early stage, research focused on the smart building aspects of the hospital, including distributed sensors and networks to enable automation of processes, be it professional workflows or patient position monitoring and transferring inside the establishment.

With the wide deployment of wearable sensors to monitor health parameters and the respective advancement of network infrastructures and networked ehealth services, the smart hospital could tear down its walls and advance to a concept much wider than the smart building, bringing 'smartness' to the core of health service delivery itself.

3. Characteristics of the emerging smart hospital

Automation is still distinctive of a smart hospital, only nowadays, automation extends to multiple levels. Traditionally, a smart hospital supports automation in administrative workflows to boost productivity, reduce errors, and tackle the shortage of workforce. However, with the current advancement in artificial intelligence and robotics, automation is now emerging also in core medical tasks, such as diagnostic imaging, patient monitoring, fine surgical procedures and patient nursing, prevention and rehabilitation. Achieving this complex automation requires breakthroughs in engineering and artificial intelligence, data and knowledge management and analytics.

Moreover, the contemporary smart hospital goes far beyond smart building functions, adding also smart medical products and procedures, including 3D printed tools and implants, new and bio-printed biomaterials, smart micro and nano-devices and personalized drugs and therapies.

Today, a smart hospital is primarily a hospital without borders. A core set of complex and critical interventions are reserved for in-hospital service delivery. However, an increasing volume of services are offered via functionally connected remote units providing healthcare services, including other hospitals, clinics, primary health care, ambulatory care settings and social care. Furthermore, the smart hospital extends to any place of interest outside the health system, encompassing any place where the patient or the healthy individual resides, such as home and workplace, recreational areas, any point of care. Such connected, distributed settings place major requirements on data security and privacy, quality of service, interoperability of data and services and network and communication infrastructures. The contemporary smart hospital ultimately aims to enhance patient experience, alleviate workload from the workforce and reduce costs and accidents.

Evidence from evaluations of related technology shows clear benefit of technological interventions for valid, reliable and accurate healthcare

<https://doi.org/10.1016/j.csbj.2023.12.011>

Available online 14 December 2023

2001-0370/© 2023 The Author(s). Published by Elsevier B.V. on behalf of Research Network of Computational and Structural Biotechnology. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

services, including screening, diagnosis, treatment, follow-up and rehabilitation. Full and successful deployment towards the smart hospital of the future requires continuous advancement of current technology. Furthermore, successful implementations require rigorous assessment and updates on the clinical protocols to meaningfully incorporate new technologies. This in turn would help to carefully assess cost-effectiveness and social dimensions of technology use, provide feedback to update regulatory, legal and insurance frameworks, and point to the appropriate design and deployment of training and change management for clinicians and patients alike.

4. Looking ahead

Although there is a vast body of literature and respective scientific journals that address individual aspects of research that contribute towards the smart hospital, a dedicated scientific forum to holistically report research pertaining to the smart hospital is currently missing.

The Smart Hospital Section of the Computational and Structural Biotechnology Journal aims to cover this niche. Specific areas of interest include all aspects of novel technology and related research contributing to the making of the smart hospital. These cover advancements in traditional areas such as network infrastructure, connected devices, hospital information systems and automation of related value chains; but also emerging enabling technologies, including but not limited to personalized, continuous, real-time monitoring at the point of care, big data analytics, extended reality, robotics and artificial intelligence as applied to create the continuum of health care. The Smart Hospital Section also highlights research on privacy and security frameworks required to achieve meaningful real-world implementations, and insights on advancing regulatory frameworks, ethics and policies that will safeguard the smooth transition to the hospital of the future.

The emergent smart hospital of the future has the potential to revolutionize healthcare delivery, focusing on enhancing the patient experience while offloading considerable amount of routine work to smart components operating mostly independently inside or outside the healthcare establishment.

The Smart Hospital Section of the Computational and Structural Biotechnology Journal aims to provide a forum for scientific discussion

and to document the research advancements towards this disruptive transition.

References

- [1] Wolfe A Institute of Medicine Report: Crossing the Quality Chasm: A New Health Care System for the 21st Century, Policy, Politics, & Nursing Practice, 2(3), 233–235, 2001.
- [2] Evans JM, Baker GR, Berta W, Barnsley J. The evolution of integrated health care strategies. *Adv Health Care Manag* 2013;15:125–61. [https://doi.org/10.1108/s1474-8231\(2013\)0000015011](https://doi.org/10.1108/s1474-8231(2013)0000015011).
- [3] Saigi-Rubió F, Borges do Nascimento IJ, Robles N, Ivanovska K, Katz C, Azzopardi-Muscat N, Novillo Ortiz D. The current status of telemedicine technology use across the world health organization european region: an overview of systematic reviews. *J Med Internet Res* 2022;24(10):e40877. <https://doi.org/10.2196/40877>.
- [4] Dukhanin V, Topazian R, DeCamp M. Metrics and evaluation tools for patient engagement in healthcare organization- and system-level decision-making: a systematic review. *Int J Health Policy Manag* 2018;7(10):889–903. <https://doi.org/10.15171/ijhpm.2018.43>.
- [5] Nardini C, Osmani V, Cormio PG, Frosini A, Turrini M, Lionis C, Neumuth T, Ballensiefen W, Borgonovi E, D'Errico G. The evolution of personalized healthcare and the pivotal role of European regions in its implementation. *Pers Med* 2021;18(3):283–94. <https://doi.org/10.2217/pme-2020-0115>.
- [6] Boniol M, Kunjumen T, Nair TS, Siyam A, Campbell J, Diallo K. The global health workforce stock and distribution in 2020 and 2030: a threat to equity and 'universal' health coverage? *BMJ. Glob Health* 2022;7:e009316. 0.1136/bmjgh-2022-009316.
- [7] Ghebreyesus T.A., WHO urgent health challenges for the next decade, 13 Jan 2020, Retrieved on 25/11/2023 from <https://www.who.int/news-room/photo-story/photo-story-detail/urgent-health-challenges-for-the-next-decade>.
- [8] Quaranta-Finsiel AA. "Smart hospitals" in the environment and in the territory. *J Clin Comput* 1988;17(1):23–7.
- [9] Kwon H, An S, Lee HY, Cha WC, Kim S, Cho M, Kong HJ. Review of smart hospital services in real healthcare environments. *Health Inf Res* 2022;28(1):3–15. <https://doi.org/10.4258/hir.2022.28.1.3>.

Eleni Kaldoudi^{a,b,*}

^a *Professor of Medical Physics and Medical Informatics, Democritus University of Thrace, Greece*

^b *ATHENA Research Center, Greece*

* Correspondence to: Smart Hospital Section, Computational and Structural Biotechnology Journal.
E-mail addresses: kaldoudi@med.duth.gr, kaldoudi@athenarc.gr.