Multidimensional Analysis of the Implementation and Impact of Digital Twins in Healthcare

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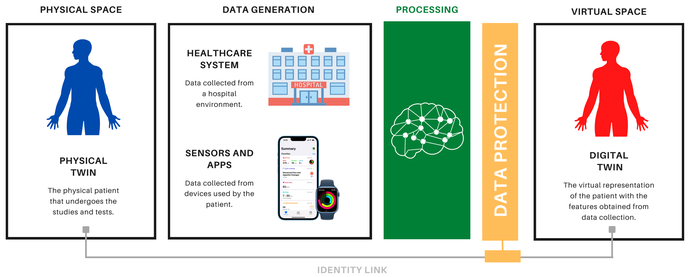

Figure 1. Representation of the construction cycle of health digital twins. The data protection block decouples the digital data from the patient (3).

01. Introduction

Digital twins, which are virtual representations of physical objects or systems, have been increasingly used in various industries for simulation and predictive purposes. In healthcare, the concept of Health Digital Twins (HDTs) has emerged as a promising approach for developing and testing diagnostic and prognostic algorithms using virtual representations of patients. HDTs are typically multidimensional and can represent a patient population within a specific health ecosystem. However, the implementation and impact of HDTs in real-world patient care pathways have not been thoroughly assessed. Despite the potential of HDTs, their integration into healthcare systems requires careful consideration of the ethical and privacy implications associated with the use of sensitive patient data (1,2).

02. Objective

The aim of this work is to analyze the state of research applied to HDTs focusing on therapeutic areas, type of data included and privacy protection measurements.

References

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2. Voigt, I., Inojosa, H., Dillenseger, A., Haase, R., Akgün, K., & Ziemssen, T. (2021). Digital twins for multiple sclerosis. Frontiers in immunology, 12, 669811.
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03. Methods

We conducted a targeted literature search using the criteria: Health Digital Twin. Articles that mentioned clinical applications were selected for analysis and data extraction considering: disease / medical specialty, diagnostics (according to ICD-10), chart data (i.e. vital signs and lab test), demographics (ethnicity & age), wearables data, privacy and ethics considerations. We also analyzed their impact on quality of care, patient satisfaction and healthcare resources use (HRU). We present a narrative description of these findings.

04. Results

From 203 articles mentioning the search terms, 17 met the criteria and underwent full-text analysis. Medical specialties included: cardiology: 4; neurology: 4; oncology: 2; infectious diseases: 2; precision medicine, surgery, critical care, gerontology, nutrition: 1 each (Figure 2). From these specialties, diagnostics most cited were: Multiple Sclerosis, Breast Cancer, and Colorectal Cancer. Type of data included: clinical: 16; demographic: 13; OMICs (i.e. genomic sequencing): 7; wearables data: 9 (Figure 3). Three articles addressed quality of care (i.e. ubiquitous patient support); Two considered patient satisfaction, and four mentioned any HRU (reduction of patient visits to healthcare centers). Privacy and ethics were noted in two and seven articles, respectively (Figure 4). It is important to note that only one article mentioned the use of 5G technology that would allow the incorporation of real-time sensor data. Also, 5 articles mentioned the use of cloud computing to keep the HDT up to date with all data sources (Figure 4).

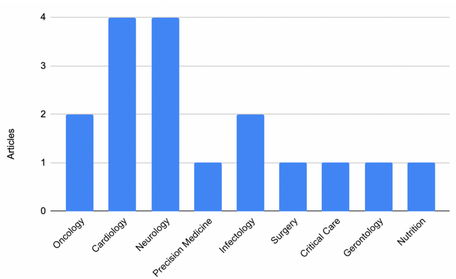

Figure 2. Number of articles of HDT per therapeutic area. HDT, health digital twins.

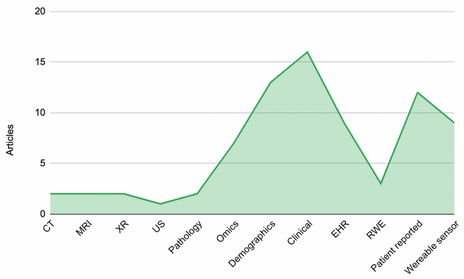

Figure 3. Types of data included in the dimensions of HDTs. CT, computed tomography, MRI, magnetic resonance imaging, US, ultrasound, EHR, electronic health records, RWE, real world data.

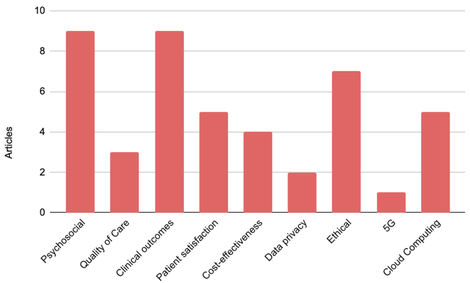

Figure 4. Variables and technologies analyzed in each publication concerning HDT. Ethical refers to ethical revision of HDT projects by ethical committees of healthcare institutions.

05. Conclusion

In conclusion, while HDTs have shown promise in healthcare, their integration into clinical practice is still in its early stages. The results of our multidimensional analysis suggest that further research is necessary to assess the safety, accuracy, and impact of HDTs on patient outcomes and healthcare resource utilization. Careful consideration of the ethical and privacy implications associated with the use of sensitive patient data is also necessary for the widespread adoption of HDTs in real-world patient care pathways.