

CHALLENGES FOR IMPLEMENTING HEALTHCARE 4.0 AND ITS BENEFITS FOR HEALTH SYSTEMS: A SCOPING REVIEW

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ABSTRACT

Introduction: The term Healthcare 4.0 has its origins directly linked to the start of the Fourth Industrial Revolution in 2011 and refers to the application of Industry 4.0 principles and technologies in the health sector. This revolution, however, places demand on healthcare systems, which must face the challenge of aligning economic, socio-cultural, and infrastructure issues, among others. **Objective:** To identify the challenges of implementing Healthcare 4.0 and its benefits for healthcare systems. **Methodology:** The research was carried out through a scoping review of Google Scholar, IEEE Xplore, PubMed, SciELO, Scopus, and Web of Science databases. **Results and Discussion:** The main challenges found in the literature refer to privacy, security, interoperability, costs, standardization, and the growing demand for high-quality services. On the other hand, Healthcare 4.0 promises to benefit the sector through the precision, personalization, and agility of care, increased quality of services, reduced health costs, and greater reliability. **Conclusion:** Industry 4.0 has emerged to break paradigms, making healthcare systems more effective and efficient in the face of a society that is increasingly demanding high-quality services, leading organizations to provide effective patient-centered care.

Keywords: Industry 4.0; Healthcare 4.0; Health technology.

Thematic Area: Temas Transversais

1 INTRODUCTION

The Fourth Industrial Revolution, or simply Industry 4.0, is a term coined in 2011 during the Hannover Fair in Germany to describe the development of high technology associated with manufacturing in the country (Schwab, 2016). It can be considered a new stage of human development, driven by a set of technologies developed from the three previous revolutions (Schwab; Davis, 2018), differentiating itself by being based on the fusion of technologies and the interaction between physical, digital, and biological environments.

Many sectors are being modified, so this "revolution promises to transform healthcare by offering more precise and personalized care" (Lopes *et al.*, 2019, p. 19) in this sense the term

Healthcare 4.0 emerges, described in the literature as the application of Industry 4.0 principles and technologies in the healthcare sector.

However, this revolution places demands on healthcare systems, which must face the challenge of aligning economic, socio-cultural, and infrastructure issues, among others (Lopes *et al.*, 2019). This study therefore aims to identify the challenges of implementing Healthcare 4.0 and its benefits for global health systems.

2 METHODOLOGY

The research was developed through a scoping review based on the guidelines proposed by Tranfield, Denyer, and Smart (2003) and Kitchenham (2007), involving three stages: (I) planning; (II) conducting, and; (III) reporting and dissemination. The development of the review was preceded by the preparation of a review protocol registered on the Open Science Framework (OSF) platform with DOI 10.17605/OSF.IO/7GNEA.

The studies were selected according to the following inclusion criteria: (a) full articles published in journals or proceedings of academic and scientific events and available in full in the selected databases; (b) works published between 2011 and February 2023; (c) works published in Portuguese, English or Spanish with a global scope; (d) works that specifically address the research question. Exclusion criteria were: (a) papers that are not fully available in the databases searched; (b) papers published before 2011 that do not deal with concepts related to the area of interest of this RSL; (c) papers that do not deal with similarity functions; (d) monographs, dissertations and theses. The year 2011 was set as the limit for the search for articles due to the emergence of the term Industry 4.0 in that year, the starting point for the Fourth Industrial Revolution.

The studies were selected in March 2023 from the following databases: Google Scholar, IEEE Xplore, PubMed, SciELO, Scopus, and Web of Science. The selection criteria were: (I) exclusion of duplicate articles; (II) reading of the title and abstract; (III) reading of the full article.

The database searches returned a total of 629 articles. After eliminating duplicates, 395 articles were selected for reading the title and abstract, of which 352 were rejected. After reading the title and abstract, 43 articles were selected for full reading. Of these, 9 did not have open access to the databases consulted, so they were discarded immediately. Finally, after full reading, 12 articles were included in the research, making up the summary.

3 RESULTS AND DISCUSSION

After selecting the studies, 12 articles were included. Table 1 shows a summary of them, indicating the authors and titles.

Table 1 - Sample of included studies.

Author(s)	Title
Al-Jaroodi <i>et al.</i> (2022)	<i>Healthcare 4.0 - Managing a Holistic Transformation</i>
Al-Jaroodi, Mohamed e Abukhousa (2020)	<i>Health 4.0: On the Way to Realizing the Healthcare of the Future</i>
Bause <i>et al.</i> (2019)	<i>Design for Health 4.0: Exploration of a new area</i>
Gupta e Singh (2022)	<i>Healthcare 4.0: recent advancements and futuristic research directions</i>
Lhotska (2020)	<i>Application of Industry 4.0 Concept to Health Care</i>
Lopes <i>et al.</i> (2019)	<i>Health 4.0: Challenges for an Orderly and Inclusive Innovation</i>
Macedo, Martins e Tourinho (2022)	<i>A evolução no desenvolvimento de Tecnologias e a Saúde 4.0: disrupção do novo</i>
Mohamed e Al-Jaroodi (2019)	<i>The Impact of Industry 4.0 on Healthcare System Engineering</i>
Rosa <i>et al.</i> (2021)	<i>Digital technologies: an exploratory study of their role in the resilience of healthcare services</i>
Sony, Antony e Mcdermott (2022)	<i>The impact of healthcare 4.0 on the healthcare service quality: a systematic literature review</i>
Tortorella <i>et al.</i> (2020)	<i>Effects of contingencies on healthcare 4.0 technologies adoption and barriers in emerging economies</i>
Tortorella <i>et al.</i> (2022)	<i>Healthcare costs' reduction through the integration of healthcare 4.0 technologies in developing economies</i>

Source: Authors (2023).

The studies made it possible to identify specific challenges that slow down the adoption of technologies and make the process complex, expensive, and sometimes impractical. These barriers must be overcome to create an effective global health framework (Al-Jaroodi *et al.*, 2022).

Al-Jaroodi *et al.* (2022) address challenges mainly related to digital issues, such as concerns related to privacy, security, access control, interoperability and integration, global connectivity, ownership, and accountability, as well as human factors and lack of vision. From the same perspective, Bause *et al.* (2019) report on cyber-attacks, storage, and security of personal data, as well as organizational aspects associated with improving patient participation and engagement in their health and changes in organizational culture. In addition, Gupta and Singh (2022) analyze data diversity and management, scalability, resource provision, security and privacy, standardization, and the need for user-friendly interfaces, as challenging factors

within the process of technological incorporation. Corroborating this, Lopes *et al.* (2019) addressed the importance of ensuring data security, as well as effectively centralizing healthcare in the patient.

For Al-Jaroodi, Mohamed, and Abukhousa (2020), factors such as high costs, a shortage of qualified professionals, growing demand for high-quality services, the size and complexity of the value chain, the need for collaboration between providers, industries, and support organizations and intense competition between providers are other challenges that impact on the implementation of Healthcare 4.0. Similarly, Mohamed and Al-Jaroodi (2019) point to high costs, difficulty in finding and recruiting the necessary healthcare professionals, growing demand for high-quality services, and strong competition between providers. Tortorella *et al.* (2020) also point to the scarcity of resources as a barrier, as does Lhotska (2020) who mentions rising costs, inefficiencies in healthcare systems, more frequent demand for care, inflexible environments, inefficient and insufficient use of medical technology and advanced data processing, standardization and interoperability.

Macedo, Martins, and Tourinho (2022) identified as challenges the delay in technological incorporation, technological insufficiency of the site with work processes, culture change, literacy of environments, technologies, and regulations, proof of concepts and clinical acceptance, decreased productivity and reduced quality of service, and professional training. Finally, Rosa *et al.* (2021) addressed the reduction in public investment, increased demand for high-quality care, and the pressure to improve the performance of central processes.

Based on the main challenges pointed out, it is believed that as technologies are improved and implemented, solutions to the challenges must also be addressed so that the benefits of adoption are effective (Bause *et al.*, 2019). In this sense, still based on the selected studies, it was also possible to identify the main benefits of Healthcare 4.0 for healthcare systems.

Al-Jaroodi *et al.* (2022) highlighted as potential benefits the possibility of improving and personalizing care, as well as offering high-quality services at affordable costs. From the same perspective, Bause *et al.* (2019) point out the possibility of centralizing the care of patient needs (personalization), offering more precise care, and reducing healthcare costs. Lopes *et al.* (2019) highlight the significant increase in productivity, more precise and personalized care, and more effective, near real-time treatments provided by technologies that collect, store and analyze data.

Al-Jaroodi, Mohamed, and Abukhousa (2020) argued that Healthcare 4.0 can improve the flexibility, scalability, reliability, agility, cost-effectiveness, and quality of services and operations, making a significant contribution.

Some of the authors highlight, among other benefits, those associated with costs and more precisely their reduction or optimization. This factor appears as both a challenge and a benefit. Despite the financial difficulties associated with acquiring emerging technologies, there are gains to be made after their effective incorporation that can contribute to health systems.

Gupta and Singh (2022) suggested that greater reliability, convenience, satisfaction, and transparency could be achieved through the effective implementation of solutions based on emerging technologies. Macedo, Martins, and Tourinho (2022) highlight increased confidence, identification of areas for improvement and the possibility of more informed decisions, as well as reduced healthcare costs and improved process flows. Finally, Tortorella *et al.* (2022) mentioned the need to expand coverage and access to health services, improve their quality, and thus reduce and optimize costs.

Lhotska (2020), Mohamed and Al-Jaroodi (2019), Rosa *et al.* (2021), and Tortorella *et al.* (2020) did not provide details on the potential benefits associated with Healthcare 4.0 in their studies.

The selected studies provide a broad overview of the challenges and benefits faced by global healthcare systems. Although these issues vary according to each specific context, common aspects are evident. This research provides important information and reflects the need for investment in technology and innovation to create healthcare environments that are more prone to change and that can consequently benefit from the improvements that accompany it.

Aligning current healthcare solutions with the Healthcare 4.0 vision is important, however, there is no single way to develop and implement healthcare technologies and applications. Each organization is incorporating new technologies differently, without an organized and coordinated approach on a large scale, which results in slow, tedious, and potentially costly progress in the long term. In this sense, it is necessary to unify efforts, adopt standardized methods for interoperability and integration, and identify ways to promote global connectivity and collaboration within and between organizations (Al-Jaroodi *et al.*, 2022).

Another important factor is the collaborative way in which technologies can predict the patient's condition and the volume of information available, which can benefit critical processes when used in conjunction with healthcare professionals (Macedo; Martins; Tourinho, 2022).

The common goal is to establish a globally accessible, highly effective, optimally operated, and economically viable infrastructure (Al-Jaroodi *et al.*, 2022). Furthermore, implementation will depend on how norms and standards are established. Technological development is rapid and regulation is not keeping pace (Lopes *et al.*, 2019; Macedo; Martins; Tourinho, 2022).

4 CONCLUSIONS

Industry 4.0 has emerged to break paradigms, making healthcare systems more effective and efficient in the face of a society that is increasingly demanding high-quality services. However, its effective implementation requires collective efforts to build a constantly evolving project that can lead organizations to provide effective patient-centered care. The main challenges found in the literature relate to privacy, security, interoperability, costs, standardization, and the growing demand for high-quality services. On the other hand, Healthcare 4.0 promises to benefit the sector through the precision, personalization, and agility of care, increased quality of services, reduced healthcare costs, and greater reliability.

The technologies associated with healthcare environments are evolving to promote the well-being of patients and the satisfaction of all those involved (stakeholders) (Macedo; Martins; Tourinho, 2022). It is hoped that technologies can complement care through an intelligent data processing system, freeing up the time of healthcare professionals so that they can be more human. The development of Healthcare 4.0 could create favorable conditions to make professionals more empathetic and provide a welcoming environment (Sony; Antony; Mcdermott, 2022).

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