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# Digital Maturity Assessment Models for Health Systems

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## ABSTRACT

With the rapid development of technology in recent years, it is observed that there are agile changes in many sectors. With these changes, technology comes to the focus of our lives and helps us to take more solid steps by facilitating processes everywhere. With the evolution of the sectors in this direction, concepts such as e-commerce, e-health, and data mining have come to the fore, and many studies have been put forward within the framework of these terms. It has been observed that the digital transformation that has begun to take place in the field of healthcare has led to significant changes in this field. The effects of technological advances, which have begun to integrate into health services, such as increasing work efficiency, increasing service quality, and creating a safe service environment have been determined. In this review study, various digitalization studies carried out in the field of health between 2012-2022 were examined and summarized, also, the prominent concepts in the studies were

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discussed. The study is divided into two main headings: (1) Digitalization in Health, and (2) Digital Maturity Assessment Models in Health Systems. As a result of the study, it was aimed to contribute to the existing literature by observing the deficiencies in the literature.

**Keywords:** Healthcare, Digital Maturity, Digital Health, Maturity Assessment, Maturity Models

## INTRODUCTION

In recent years, it has been observed that there have been significant changes in the health sector with the developing technology. Technological developments worldwide have also affected existing health technologies, thus facilitating the processes by bringing new health technologies to the sector (Karadayi et al., 2020). With the development of technology in health systems, concepts such as predicting the risk of loss of life, drug need estimation, estimating disease epidemics, early diagnosis studies according to disease symptoms, reducing the operating costs of hospital managers, helping the government in health policies and improving health quality are the effects of digitalized processes. To keep up with the transformations with an agile approach, being innovative in health services has become an important skill. As an effect of this, the processes of developing maturity models have started to be measured digitality in health systems and witness innovations. Maturity models, when viewed broadly, are based on the premise that people, organizations, and processes evolve towards a higher maturity that completes several stages throughout the development and growth process. Maturity models in health services, on the other hand, come to the fore in the health service process, based on many important points such as service improvement and quality improvement in hospital operations. In this context, the digitalization studies carried out in the field of health are summarized in the compilation study based on the relevant terms. By going from general to specific, it is aimed to determine and examine the maturity models applied by researchers for digitalization in health and to make a summary presentation. Using the existing literature, digital maturity assessment models in health systems were examined.

## LITERATURE REVIEW

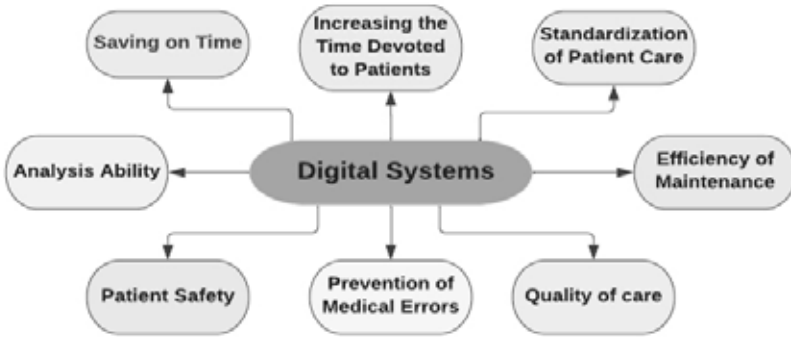
Along with the literature review, it is expected to make a summary presenta-

tion of the studies on digitalization in healthcare. In addition, it is aimed to determine the popular methods that researchers include in their studies within the scope of the relevant subject and to examine the tools that support the application while performing the application. Google Academic, Web of Science, PubMed, Science Direct, and Istanbul Medipol University Library-Electronic Information Resources were scanned with the help of keywords related to digitalization in health presented in appendix A. Keyword cloud has been created as it is aimed to summarize the studies on digitalization in health. This created word cloud was searched with AND, OR logic in a way that the scanning databases can understand. In order not to miss any information about maturation in health, it has been created to define these concepts and with synonymous terms of the defined concepts. While reviewing the articles, the scope has been narrowed down with keywords based on different perspectives and methods concerning the relevant topic for appropriate literature selection. Due to the increasing popularity of the subject in recent years, the literature study was carried out between 2012 and 2022. As a result, the articles published during this time were included in the study. At this point, the study is divided into two main headings: (1) Digitalization in Healthcare, and (2) Digital Maturity Assessment Models in Health Systems.

### **Digitalization in Healthcare**

With the development of technology, it is observed that there are opportunities for the sectors to develop themselves and increase their quality. These changes have paved the way for the birth of a new digital age. Digital transformation tools that play an important role in the realization of digital transformation can be listed as virtualized networks, data analysis, multi-layered security, and virtual storage technologies. Thanks to these tools, issues such as e-commerce, e-health, data mining, and cyber security have emerged. Digital transformation has also led to significant changes in the field of health. With this transformation, it is expected to save time by using digital systems in health, increase the time allocated to patients, standardize patient care, improve the efficiency of care, analysis ability, patient safety, prevention of medical errors and quality of care, and to increase the quality of these topics (Figure 1). The digital change and transformation in the field of healthcare have been the focus of attention of researchers, in this context, the current situation has

been examined by focusing on the topic, based on this, interpretations for the future have been made.



**Figure 1:** Digital Systems in Healthcare.

With a study published in 2022, Zimmermannova et al., focusing on the Czech Republic case study aimed to identify the benefits of digitizing medical devices in hospitals during the COVID-19 process. As a result, it has been observed that various types of savings, especially economic benefits, and optimization of both processes and employees are realized with digitalization.

With a study published in 2022, Tortorella et al., investigated the effects of digital applications on health during the COVID-19 pandemic on resilience. Data were collected through interviews and analyzed through content analysis. As a result, it has been seen that the applications for patient diagnosis and supply chain support all resilience abilities.

With a study published in 2022, Denizli & Demirtaş, aimed to evaluate the technology readiness of healthcare workers in the digital hospital transformation process. Descriptive analyses, t-tests, and ANOVA analyzes were performed with data from 340 healthcare professionals. As a result, it has been determined that the technology readiness of healthcare workers is higher than the average.

With a study published in 2021, Doğan, aimed to reveal the classification of hospitals certified with Electronic Health Record Adoption (EMRAM) 6th and 7th levels following digital hospital standards in the world and Turkey, according to regions. As a result of the research, it has been analyzed that the number

of certified hospitals in Turkey is higher than the other countries in the region, except for North America. It suggested that this advantage of Turkey in terms of location should be used to serve more foreign patients.

With a study published in 2021, Yaneva, in the study conducted, the main points related to the integration of digital technologies into processes in health institutions were discussed. As a result, it has been emphasized that although some disadvantages occur, the concept of digitalization can minimize the total amount of critical events that endanger patient safety.

With a study published in 2021, Zhao & Canales, examined the formation of information strategies in the digitalization process of health institutions. The results revealed four phases in which interactions between professional groups shape knowledge strategies.

With a study published in 2019, Eden et al., focused on digital transformation in health and compared two approaches: operationalizing effective use by using effective use theory and context-oriented operationalization in terms of workarounds designed by users to achieve their goals. Data were collected from a multi-hospital digital transformation, and as a result, the theory-based approach has come to the fore.

With a study published in 2019, Akinsanya et al., approached from a different perspective and explored the effective evaluation of healthcare cybersecurity maturity models for healthcare organizations that actively use cloud computing. As a result, security concerns specific to the respective healthcare cloud have been presented.

With a study published in 2018, Mettler & Pinto, discussed the term 'digital maturity with the help of statistical analysis based on the evidence emerging from an extensive longitudinal survey. In conclusion, they presented evidence on the evolutionary pathways, influencing factors, and improvement potentials in hospitals.

As a result, it was determined that the researchers focused on the benefits of digitalization in health and commonly observed the disadvantages of new processes. It has been observed that there are many studies in the literature that support digitalization studies in the field of health with the benefits it brings. However, it has been emphasized that while this digitalization brings benefits, it also brings many disadvantages, and it is necessary to focus on these points

to establish robust process frameworks. In addition, it has been determined that most of the researchers have turned their focus to the maturity model in digitalization in health to see the digital level of health organizations by looking at different perspectives.

### **Digital Maturity Assessment Models in Health Systems**

The maturity model is a set of structured levels that define organizational practices, processes, and behaviors that sustainably and reliably produce the required results. It measures an organization's ability to continually improve in certain dimensions until it reaches the desired level of maturity (Liaw et al., 2021). Since digitalization in health is a prominent and spreading concept in recent years, it has been the focus of attention by researchers. Different maturity models have been used in the literature to measure the level of maturity of health institutions that have adopted this system.

With a study published in 2021, Liaw et al., the purpose is to develop a digital health profile and maturity assessment Toolkit to help them leverage digital tools to support their national health priorities. The result shows, that a comprehensive list of indicators describing country digital health profiles and a digital health maturity assessment tool was introduced, using criteria developed with country stakeholders to assess key digital health foundations and quality improvement.

With a study published in 2021, Nyangena et al., aimed to determine the readiness of the Health Information Systems interoperability capacity of hospitals in Kenya to this maturity. None of the domains has claimed a higher level of maturity than the developing level. The sub-domains of governance structures for HIS, the national enterprise architecture defined for HIS, the defined technical standards for data exchange, nationwide network infrastructure, and capacity for hardware operations and maintenance have reached higher levels of maturity.

With a study published in 2021, Lee & Park, targeted to reveal a technology-based practical blockchain system audit maturity model. Ultimately, practical audit items that can contribute to the stabilization of blockchains are proposed.

With a study published in 2019, Carvalho et al., presents the maturity model of information systems in the health field. Information systems were analyzed

using data from Portuguese hospitals to validate Hospital Information System Maturity Model (HISMM). It has been encouraging in demonstrating that it has a high level of acceptance among the data obtained. This early adoption pushes the development of a new model phase focused on the development of an automated HIS maturity assessment tool.

With a study published in 2019, Carvalho, Rocha, Vasconcelos, et al., aimed to analyze the complexity of healthcare services using clinical and financial datasets. For this analysis, they presented a proposal to measure the patients' information systems. By addressing the complexity of this model hospital information system, they proposed and developed useful scales for the mixed management of HIS management.

With a study published in 2019, Carvalho, Rocha, Vasconcelos, et al., examined the inpatient admission process using data from a public hospital in Greece. They aimed to present a digital system for this process and to improve the process by developing a maturity model. As a result, it has been determined that the digital services used in Health services have higher operability maturity than other sectors in Greece.

With a study published in 2016, Pak & Song, systematically created a health capacity maturity model using personal health record data. They suggested ways to improve these records. They have integrated some key processes and concepts from the Talent Maturity Model Integration (CMMI) and Trans-theoretical Model (TTM) into HCMM, which assesses an individual's competence and awareness to manage health and well-being and proposes customized improvement goals.

With a study published in 2012, Guédria et al., access to high quality and safe services, eHealth interoperability is a fundamental prerequisite. A mature interoperability between health systems will support health services organization and delivery, and improve citizens' awareness of how to prevent disease and preserve good health. Within this context, health institutions have to solve interoperability problems or prevent them to appear, and if possible avoid them before they occur by adapting good practices toward interoperability. This paper proposes an evaluation of the potential health interoperability using the MMEI methodology (Maturity Model for Enterprise Interoperability) aimed to measure e-Health interoperability assessment. They aimed to

carry out an assessment of possible e-health interoperability using the MMEI methodology (Maturity Model for Enterprise Interoperability). It is discussed how the MMEI model can be used to help organizations avoid interoperability issues.

It has been observed that researchers focus on digitalization in health institutions, and in this context, they receive support from different maturity models. While some studies measure the maturity level of existing digitalization, some studies have measured the maturity level by proposing new digital systems. A summary of these studies is presented in Table 1.



**Table 1:** Summary of the studies about digital maturity assessment models in health systems.

Authors	Purpose	Result	Indicators	Maturity Assessment Model	The focus of the model
Liaw et al., (2021)	Develop a Digital Health Profile and Maturity Assessment Toolkit to help them leverage digital tools to support their national health priorities.	A comprehensive list of indicators describing country digital health profiles and a digital health maturity assessment tool was introduced, using criteria developed with country stakeholders to assess key digital health foundations and quality improvement.	Essential Digital Health Tools, Readiness for Information Sharing, Health System Adoption, Quality Improvement, Measurement, Monitoring, And Evaluation	Information Capability Maturity Model (ICMM)	Digital Health Profile
Nyangena et al., (2021)	To determine whether the interoperability capacity of Kenya's HIS is ready for maturity.	None of the domains has claimed a higher level of maturity than the developing level.	Leadership And Governance, Human Resources, Technology, Network,	Health Information Systems (HIS)	Digital healthcare and maturity level
Carvalho et al., (2019)	A maturity model has been developed for Hospital Information Systems.	Pushes the development of a new model phase focused on the development of an automated HIS maturity assessment tool.	Electronic Medical Records, Systems and IT Infrastructure, Strategy Information Security	Hospital Information System Maturity Model (HISMM)	Hospital Information Systems
Carvalho, Rocha, Vasconcelos, et al., (2019)	To offer a proposal to measure Hospital Information Systems maturity.	HIS is a maturity model that includes six stages of growth and maturity progression.	Clinical And Financial Data	Hospital Information System Maturity Model (HISMM)	hospital Information Systems
Kouroubali et al., (2019)	Developing a digital system, determining improvement priorities with the help of a maturity model	The digital health sector in Greece has been found to have higher operability maturity than other sectors.	Poor Interoperability Opportunistic: Fair Interoperability Essential: Essential Interoperability Sustainable: Good Interoperability Seamless: Seamless Interoperability	Interoperability Maturity Model (IMM)	Digital healthcare and maturity level
Pak & Song, (2016)	To integrate CMMI and TTM processes with HCMM.	By applying HCMM to the PHRs, the PHRs reached the desired level of maturity.	Personal Health Record	Health Capability Maturity Model (HCMM)	Health Management

Using the existing literature, also the tools that are used in digital maturity assessment models were examined. Thus, the tools that were most commonly encountered were classified as Clinical Decision Support Systems (CDSS), Information Technologies, and Technology/ Process Management.

For example, with the studies published in 2022, 2021, and 2020, respectively, Salami et al.; Zhang et al.; Souza-Pereira et al.; Chong et al. and its early detection is crucial for appropriate treatment. To analyse 3D-magnetic resonance imaging (MRI) focused on the advantages of CDSS in clinical processes, and as a result, it has emerged as the common idea of researchers that they should be used more actively to reach a sufficient level of maturity.

Also, with the studies conducted in 2022, 2021, and 2020, respectively, Barnes & Daim; Hasic et al.; Zhila et al.; Bah et al.; Gluschkoﬀ et al.; Mer-toğlu, and semi-structured interviews with key informants in health policy, information technology and HRH management. It was conducted over two months from May to July 2019. The WHO-HRHIS assessment tool was used during the observational phase. We purposively selected representatives from different organizations and departments involved in managing the HRHIS. In the qualitative phase, purposeful and snowball sampling methods were used, and 20 interviews were conducted that each lasted minimum of 45 minutes. A content analysis was used to discuss findings.

Results

Human Resources (HR) aimed to investigate Information Technologies tools during the progress of digitalization in health. It has been determined that the studies gathered under the heading of Information Technology focus on measuring the maturity of the existing technical level and in this context, they put forth maturity models or measure the maturity level with the support of existing maturity models.

In addition, with the studies conducted in 2021, 2017, and 2016, respectively, Chew et al.; Shaygan & Daim; Arshad et al.; Ileri, Technology/Process Management topic was examined. By emphasizing the importance of information flow, the authors underlined the critical importance of sound technology management in the process of increasing the digital maturity level of hospitals.

## RESULTS

In recent years, the health sector has undergone a great digital transformation with the changing world, and as a result, they have had to fight possible

risks by adopting an agile structure. In addition, the advantages and benefits brought by technological innovations have become undeniable, and more solid steps have been taken by facilitating processes in different areas of the services offered. For this reason, it has been observed that digital maturity assessment models come to the fore in the literature.

Maturity models in this area perform level measurement of systems that can create action plans promptly by using the information provided from internal and external contexts to create meaningful metrics related to system learning and increased efficiency in results. In this direction, the concept of digital health has been examined from different perspectives, and it has been determined that different maturity assessment models have been included and examined by researchers. Many studies have been brought to the literature to develop and improve digital maturity assessment processes in health. With the literature review carried out, it has been determined that the related concept has been focused on by researchers and has come to the fore in the last ten years.

With the literature review, the concept of a digital hospital was examined, and two main headings were created, namely digitalization in healthcare and digital maturity assessment models in health systems, and the focus was shifted to digital maturity assessment models in health systems, which is the area where most of the research is collected.

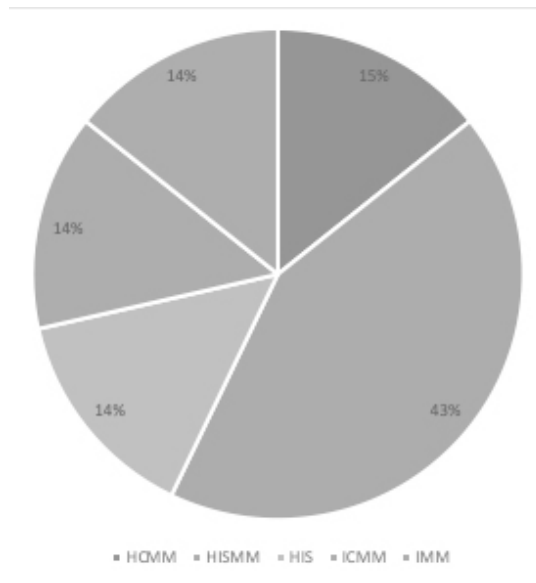
## **DISCUSSION**

In recent years, with the emergence of the concept of digitalization in health, researchers have focused on this issue from different perspectives and have produced many studies. The result has been many different models and many different vehicles that have emerged in those models.

Emphasizing the advantages of technological advances in clinical processes has emerged as the common thought of researchers that they should be used more actively to reach a sufficient level of maturity. Although it is emphasized that different tools such as Clinical Decision Support Systems, Information Technologies, and Technology/ Process Management facilitate processes and provide different positive returns, it has been observed that health institutions still do not reach the level of maturity.

As a result of the literature review, it was observed that researchers put forward models and frameworks that guide policymakers in technology management. Emphasizing the importance of information flow, the authors underlined the critical importance of sound technology management in the process of increasing the digital maturity level of hospitals.

It has been observed that health organizations that ideally integrate new technological developments into their systems have great success in the digital transformation process. In this direction, it is thought that the literature review will contribute to the literature by guiding future studies for researchers focusing especially on digital maturity assessment processes in health systems. In addition, it is recommended that decision makers and policymakers in health systems should receive support from these techniques by improving the relevant models and methods summarized in this research at the stages of process development, improvement, and productivity increase.



**Figure 2:** Distribution of Maturity Assessment Model

Some maturity models have been developed to perform digital maturity level measurements in health. According to the literature review, different maturity models were determined. It has been observed that there are HIMMS,

HCMM, HIS, ICMM, and IMM models to develop and improve the process of evaluating digital maturity models in health. As a result of the literature study, it has been observed that the most used model is HIMMS. (Figure 2).

**Ethical Approval:** Since the article is a literature review, there is no violation of ethical rights, so ethical approval does not require.

**Authors' Contributions:** All authors analyzed related papers in the literature, collected appropriate studies, and classified them into subtitles of the general research subject. Lastly, the authors wrote the literature review paper.

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#### **APPENDIX A**

Keywords: (“health 4.0” OR “health 5.0” OR “e-health” OR “healthcare” OR “HIMSS” OR “health” OR “telemedicine”) AND (“digitalization” OR “technology” OR “smart” OR “informatics” OR “artificial intelligence”) AND (“maturity” OR “digital maturity”) AND (“assessment” OR “data” OR “digital” OR “decision making”) AND (“index” OR “models” OR “level” OR “scale”) AND (“cybersecurity” OR “interoperability” OR “blockchain”) AND (“measurement” OR “system” OR “techniques” OR “evaluation”) AND (“standardization” OR “road map” OR “strategy” OR “plan” OR “standard” OR “degree” OR “performance” OR “improvement” OR “development” OR “progress”)