Digital Health Communication Maturity Model: A Systematic Review

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Abstract

Background: Recently, digital health has emerged as a crucial factor in public healthcare. Health organizations are now prioritizing evaluations of their digital health maturity to ensure full optimization of the benefits of this new technology.

Objective: This review aims to address existing gaps in Digital Health Maturity Models (DHMMs), specifically focusing on issues related to consensus, standardization, and the tendency to prioritize infrastructural implementation over communication elements.

Methods: A systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This review included 29 articles from various databases, including EBSCO, PubMed, and ProQuest.

Results: The results show that existing DHMMs lack critical user communication elements, such as satisfaction, engagement, personalization, and customization. This review proposes a Digital Health Communication Maturity Model (DHCMM) to address this gap, which enhances existing DHMMs by incorporating health communication components. This innovative model offers a more comprehensive assessment of an organization's digital health maturity and presents avenues for enhancement.

Conclusions: The newly introduced DHCMM in this study offers a framework for evaluating engagement by users and stakeholders within the digital health ecosystem. Emphasizing collaboration, governance, and the effective use of digital health capabilities provides a structured approach to assessing maturity in digital health communication.

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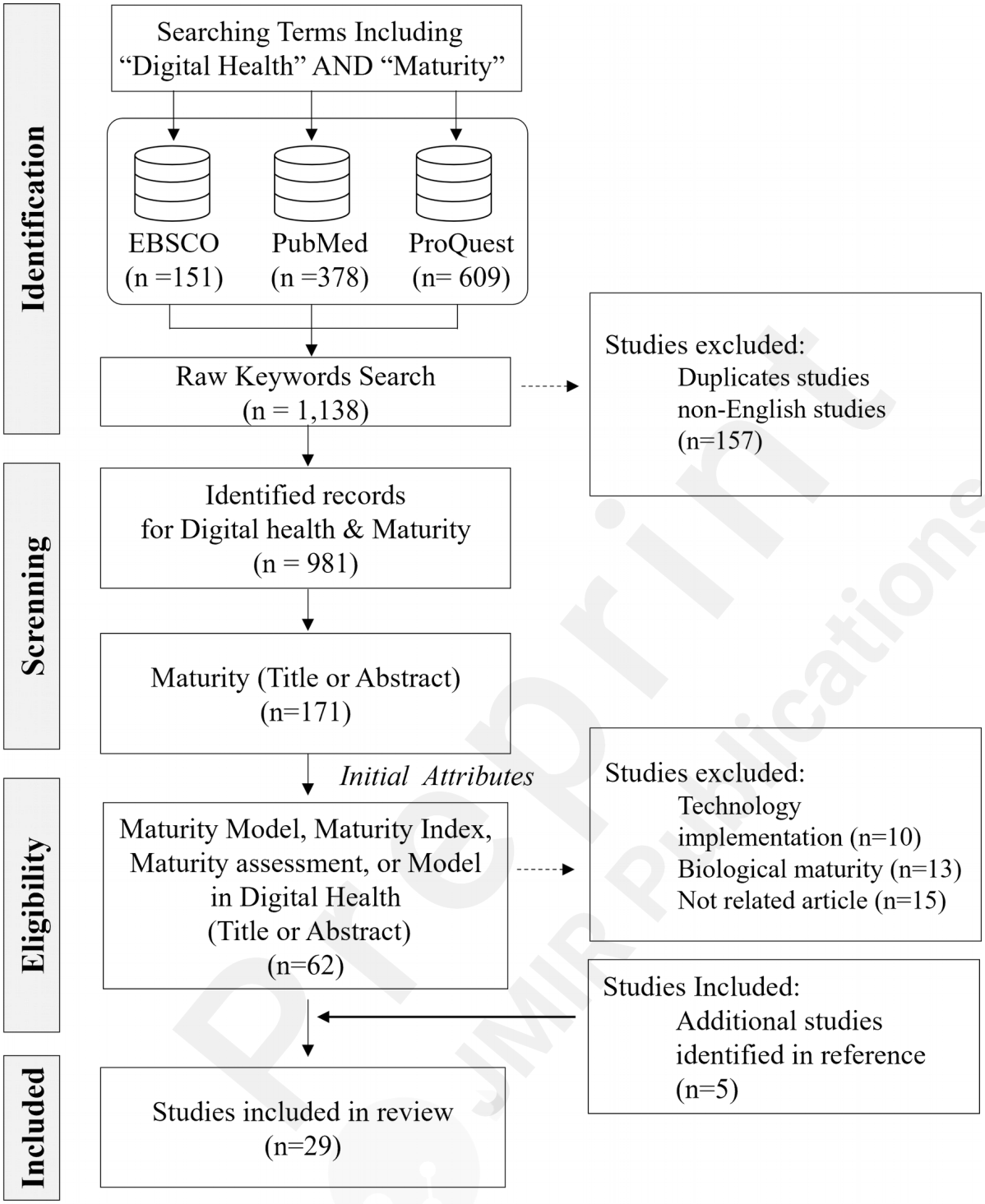


Introduction

Advancements in digital technology have ushered in an era characterized by rapid digital transformations across various sectors. This progress has led to the emergence of digital health as a pivotal force in the public health arena, fundamentally reshaping the accessibility, delivery, and management of healthcare services[1]. Digital media technology can monitor patients and facilitate communication between health providers and patients, representing a revolutionary shift that transcends geographical and temporal limitations[2], also known as eHealth or Health Information Technology (HIT) and holding immense potential to improve patient outcomes, streamline healthcare processes, and redefine the doctor-patient relationship [3].

Digital health encompasses various applications, including mobile health, wearable devices, telemedicine platforms, and electronic health records [4]. These technological advancements enable real-time data exchanges, remote patient monitoring, personalized treatment plans, and evidence-based decision-making. Consequently, digital health offers significant benefits, such as enhanced patient engagement and adherence, while providing healthcare providers with data-driven insights for more precise diagnoses and treatment recommendations[5,6]. Beyond the mere incorporation of gadgets and software, digital health represents a profound shift in healthcare delivery, extending into daily lives through wearables, health apps, and online consultations[7]. This approach allows patients convenient access to medical advice, monitoring of their health conditions, and management of chronic illnesses from their homes. At the same time, healthcare providers gain access to a wealth of data, potentially reducing errors and enhancing patient outcomes [8].

However, digital health also introduces new challenges, including data security, privacy concerns, system interoperability, regulatory compliance issues, and the need for fair access to healthcare technology. These issues are paramount in the healthcare industry [9]. Moreover, healthcare organizations and stakeholders need a structured framework to evaluate their maturity and ensure the effective adoption and integration of these technologies. The rapid pace of technological innovation has led to a fragmented landscape, with various digital health solutions operating on disparate standards and protocols[10]. The key challenge lies in facilitating seamless communication and data exchange between these systems while safeguarding patient privacy, representing no small feat.

To overcome these challenges, healthcare organizations aim to enhance their preparedness in the rapidly evolving digital health space. One path forward is to improve maturity. Maturity encompasses technological capabilities and the organization's readiness to adapt and communicate effectively in this digital era [11]. This is where the Digital Health Maturity Model (DHMM) concept becomes significant [12]. Maturity models are currently employed in many sectors, such as financial services and manufacturing, among others[12]. These models offer a structured framework for assessing an organization's readiness, progress, and effectiveness in adopting digital health solutions as a societal guideline through the stages of maturation to optimize their exercises.

Typically, DHMMs consist of stages or levels that assess an organization's capabilities in key areas, such as technological infrastructure, data management, interoperability, clinical workflows, and patient engagement[11]. They are organized for stakeholders to identify gaps, prioritize needs, and determine a strategic and effective course for digital health implementation. However, existing DHMMs often fail due to technological, organizational, and social factors [13–15]. This results in a lack of a standardized DHMM that is feasible for use in academia and public health practice.

To explore DHMM more deeply, this review seeks to answer the following questions: 1) Which DHMMs have been utilized in research? 2) What are the common components among these models? and 3) What technological, organizational, and social factors are insufficiently addressed by existing DHMMs? Based on the findings, this study aims to propose a more comprehensive DHMM that addresses the limitations of current models and captures the dynamic nature of digital health.

Methods

Systematic Review

A systematic literature review was conducted following Arksey and O'Malley's [16] and the Joanna Briggs Institute's [17] methodological frameworks to examine the current literature on digital health maturity models. Adherence to methodological standards was ensured using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension) checklist[18].

Search Strategy

To identify relevant articles covering DHMMs, an extensive search strategy was employed across EBSCO, PubMed, and ProQuest databases using the search term "Digital health and Maturity" from 2000 to May 2024. These databases were used, given their established status in fields related to digital health[57]. Their prominence stems from several factors, including their extensive coverage of the literature, sophisticated cataloging systems, and user-friendly interfaces. Consequently, researchers, clinicians, and practitioners widely recognize and utilize them in digital health-related fields [62]. Furthermore, these databases offer advanced search options, access to full-text articles, and seamless integration with citation management tools, enhancing their utility when conducting focused reviews and meta-analyses in digital health research. The results and reputation are bolstered by their longstanding presence in the academic and health communities and their partnerships with reputable publishers, organizations, and networks[60]. The important part played by medical and health databases is further underscored by their widespread usage, comprehensive content, and contribution to advancing knowledge in the digital healthcare domain (Table 1).

Table 1. Search strategies across datasets

Steps	Research Terms
1	(Digital health AND Maturity [Title/Abstract])
2	("Maturity Model"[Title/Abstract] OR "Maturity Index," [Title/Abstract] OR "Maturity assessment"[Title/Abstract] OR "Model in Digital Health"[Title/Abstract])

Inclusion and Exclusion Criteria

The articles were reviewed and assessed in accordance with digital maturity as it pertains to creating a comprehensive framework specifically tailored to the digital health landscape. Additionally, only articles published in English were selected. Likewise, specific exclusion criteria were employed to refine article selection. The research (1) excluded those articles that did not contemplate maturity levels or categories; (2) that were not related to the objectives of this study; (3) that studied biological maturity; (4) that focused on only IT implementation; and (5) that were not full-text articles. In cases where multiple versions of a report were available, only the most recent version was included.

Study Selection

Initial searches yielded 1,138 articles that were "relevant". After excluding duplicate and non-English, 981 articles remained for further evaluation. Among these, 810 articles were excluded based on the absence of the key term 'maturity' in their titles and abstracts, leaving 171 articles for continued assessment. Further refinement was applied to include only articles featuring terms such as "Maturity Model," "Maturity Index," "Maturity assessment," or "Model in Digital Health," resulting in a final selection of 62 articles. Additionally, 15 unrelated studies, 13 studies on biological maturity, and ten studies on implementation were excluded, leaving 24 studies eligible for inclusion in the review. Furthermore, five studies identified in references were also included, bringing the total number of studies for review to 29 (Table 2). The screening process is illustrated in the PRISMA flowchart (Figure 1).

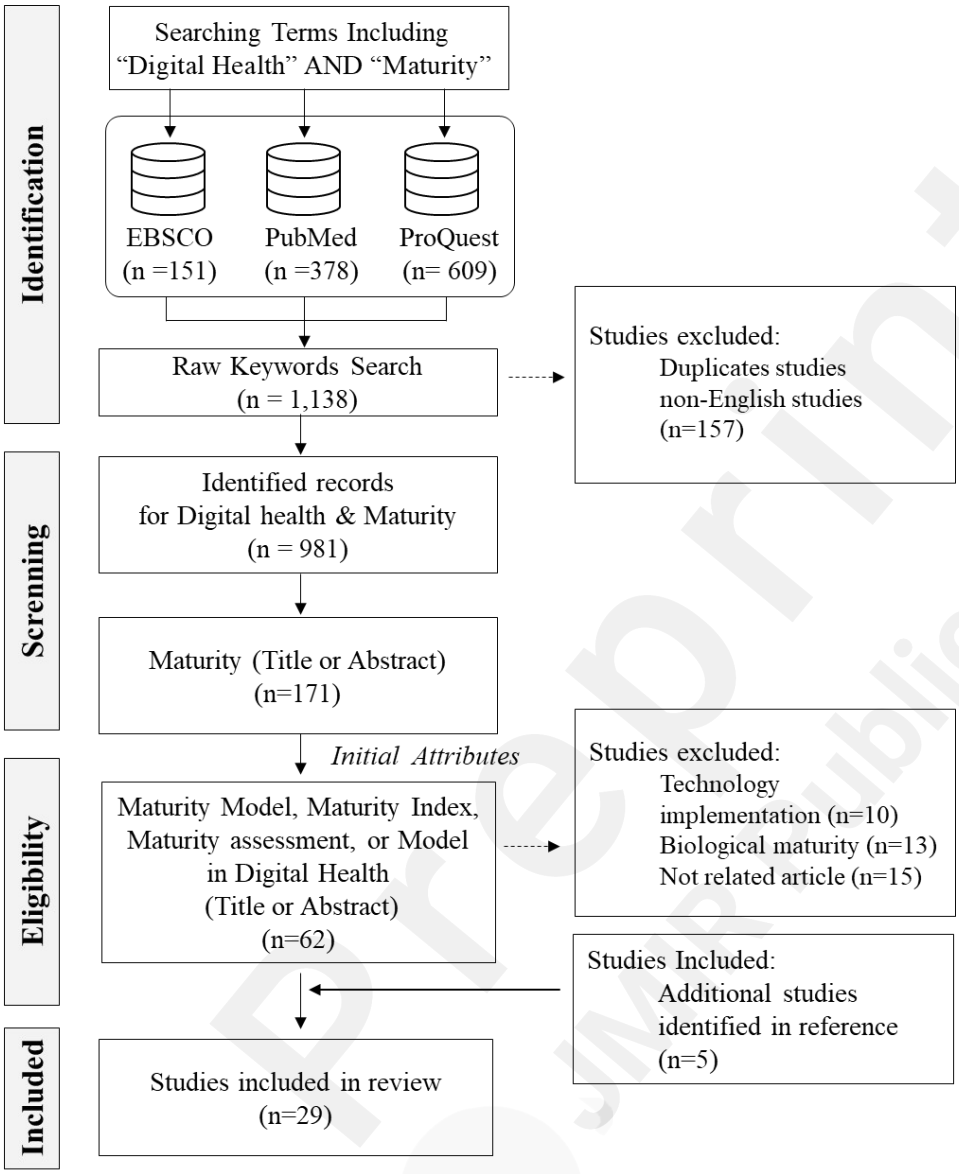
Table 2. Summary of the included studies

Author (Year)	Methods	Publication

		Name
Williams, P. A., Lovelock, B., Cabarrus, T., & Harvey, M. (2019) [26]	Operational framework	JMIR Med Informatics
Gomes J, Romão M. (2018) [28]	A state-of-the-art review	J Med Syst.
Martin, G., Clarke, J., Liew, F., Arora, S., King, D., Aylin, P., & Darzi, A. (2019) [27]	A multivariable regression model	NPJ Digit Medicine
Shaygan A, Daim T. (2019) [29]	An exploratory multi-criteria approach	IEEE (Institute of Electrical and Electronics Engineers) Xplore
Van Dyk L, Schutte CS (2013) [31]	Iterative process	South African Journal of Industrial Engineering
Jami Pour M, Jafari SM (2019) [32]	Mixed method	Emerald Insight
Alexander, G. L., Liu, J., Powell, K. R., & Stone, P. W. (2022) [33]	National Survey	JMIR Aging
Duncan, J., Xu, W., Narus, S. P., Clyde, S., Nangle, B., Thornton, S., & Facelli, J. (2013) [34]	Used various artifacts	Online J Public Health Inform
Duncan, R., Eden, R., Woods, L., Wong, I., & Sullivan, C. (2022) [35]	Systematic Review	Journal of Medical Internet Research
Eysenbach, G. (2007) [36]	Theoretical	National Library of Medicine
Grasser, M. G., Schlaipfer, V., Priedl, R., & Sorantin, E. (2018) [37]	An innovative, multi-dimensional, and human-centered socio-economic capability model	Studies in Health Technology and Informatics
Jansen-Kosterink, S., Broekhuis, M., & van Velsen, L. (2022) [38]	Technology Readiness Levels	SAGE Journals
Johnston, D. S. (2017) [39]	Digital maturity assessments (DMAs)	Digital Health Journal of Medical Internet Research
Kayser, L., Furstrand, D., Nyman Rasmussen, E., Monberg, A. C., & Karnoe, A. (2022) [40]	A narrative overview that identifies health-technology-assessment-inspired models	Informatics
Kouroubali, A., Papastilianou, A., & Katehakis, D. G. (2019) [41]	The Interoperability Maturity Model (IMM)	Studies in Health Technology and

Kutza, J. O., Hübner, U. H., Holmgren, A. J., & Esdar, M. (2022) [42]	Literature review and a derivation of maturity objects (MO)	Informatics Studies in Health Technology and Informatics
Liaw, S. T., Kearns, R., Taggart, J., Frank, O., Lane, R., Tam, M., ... & Harris, M. (2017) [43]	Mixed methods evaluation	International Journal of Medical Informatics
Liaw, S. T., Zhou, R., Ansari, S., & Gao, J. (2021) [44]	A literature review	Journal of the American Medical Informatics Association
Nyangena, J., Rajgopal, R., Ombech, E. A., Oloo, E., Luchetu, H., Wambugu, S., ... & Ndirangu, M. N. (2021) [45]	HIS Interoperability Maturity Toolkit, developed by MEASURE Evaluation and the Health Data Collaborative's Digital Health and Interoperability Working Group	BMJ Health and Care Informatics
Occelli, S., & Scelfo, B. (2020) [46]	Survey	International Journal of E-Planning Research (IJEPR)
Peytremann-Bridevaux, I., Filliettaz, S. S., Berchtold, P., Grossglauser, M., Pavlickova, A., & Gilles, I. (2021) [47]	Scaling Integrated Care in Context maturity model tool (SCIROCCO tool)	BMJ Journals
Pumplun, L., Fecho, M., Wahl, N., Peters, F., & Buxmann, P. (2021) [48]	Qualitative Interview Study	Journal of Medical Internet Research
Reifegerste, D., Harst, L., & Otto, L. (2022) [49]	Telemedicine Community Readiness Model (TCRM)	Journal of Public Health
Richmond, F. J., Zapotoczny, G., Green, B., Lokappa, S., Rudnick, K., & Espinoza, J. (2022) [50]	A Novel MedTech Startup Maturity Index (SMI)	Journal of Clinical and Translational Science
Stahl, M., Cheung, J., Post, K., Valin, J. P., & Jacobs, I. (2022) [51]	Questionnaire Study	JMIR Formative Research
Tarhan, A., Garousi, V., Turetken, O., Söylemez, M., & Garossi, S. (2020) [52]	A multivocal literature review	Sage Journals
Tom-Aba, D., Silenou, B. C., Doerrbecker, J., Fourie, C., Leitner, C., Wahnschaffe, M., ... & Krause, G. (2020) [53]	Evaluated SORMAS using the GGMM version 1.0 indicators	JMIR Public Health and Surveillance
Flott, K., Callahan, R., Darzi, A., & Mayer, E. (2016) [54]	A Systematic Review	Journal of Medical Internet

Figure 1. Screening process through the PRISMA-based flowchart



Data Extraction

During the screening stages, articles were categorized into two dimensions. Firstly, reference information, such as study title, publication year, journal, and authorship, was recorded. Secondly, each publication was evaluated for its relevance to the study's objectives, methodology, outcomes, and recommendations regarding inclusion or exclusion. Each paper was thoroughly reviewed during the analysis to ensure alignment with the current investigation's objectives. The search results were then meticulously analyzed and reviewed using Microsoft Excel for further assessment. Rigorous data collection techniques were employed, with trained personnel conducting data extraction. Any discrepancies that arose were resolved through discussions.

Quality Evaluation

The selected articles were evaluated based on the quality of the scholarly publication using the SC Imago Journal Rank (SJR) indicator as the primary tool for ranking the quality of the included articles. This approach aligns with the approach adopted by Oshni-Alvandi, Bain, and Burstein[19]. Furthermore, each included paper underwent two assessment rounds, with the majority being reviewed by a different researcher to ensure additional quality assurance (Table 3).

Table 3. Quality of included journals and articles based on SJR

Level	Journals N (%)	Papers N (%)
Q1	17 (61%)	17 (59%)
Q2	4 (14%)	4 (14%)
Q3	3 (11%)	4 (14%)
Q4	0	0
Not yet assigned a quartile	1 (3%)	1 (3%)
Not ranked	3 (11%)	3 (10%)
Total	**28 (100%)**	**29 (100%)**

Results

Review of the Existing Maturity Models

The systematic review identified eight commonly used digital health maturity models: The Capability Maturity Model (CMM), the Capacity Maturity Model Integration (CMMI), the Electronic Medical Record Adaptation Model (EMRAM), the Continuity of Care Maturity Model (CCMM), the Clinical Digital Maturity Index (CDMI), the Interoperability Maturity Model (IMM), the Social Media Customer Care Model and the Telemedicine Service Maturity Model (TMSMM). These models were compared to discern how they evaluate digital health maturity levels and identify gaps and improvement opportunities. Combining various features from these models resulted in a new and more comprehensive model capable of providing detailed insights into an organization's maturity level and highlighting avenues for growth. Detailed explanations of each of the models are given below.

Digital Health Maturity Models

Capability Maturity Model (CMM)

CMM is a software engineering framework that outlines a five-level path for systematically and incrementally improving software engineering processes. It was developed by the Software Engineering Institute (SEI) at Carnegie Mellon University in the 1980s. It is widely used to assess the maturity of an organization's software processes [19]. The model helps organizations identify and prioritize improvement areas based on their current level of process maturity. Organizations have few defined processes at Level 1 (i.e., the lowest level of process maturity). In contrast, at Level 5 (i.e., the highest level of process maturity), organizations have well-defined, highly optimized processes that are continually improved. This CMM focuses on process improvement and process maturity domains and sub-domains, making it a valuable tool for organizations seeking to improve their software engineering processes[20,21] (Table 4).

Table 4. Five Maturity Levels of CMM [19]

Steps	Detailed description
Level 1 – Initial	The Initial level is characterized by ad hoc and individualized processes. There is little or no process documentation, and processes are often not repeatable. At this level, the organization does not provide a stable environment for its software development activities.
Level 2 – Repeatable	The use of basic project management techniques characterizes the Repeatable level. The organization begins to develop a set of repeatable standard processes from one project to the next and establish a project management infrastructure.
Level3 – Defined	The use of formalized and standardized processes characterizes the Defined level. All processes are well-documented and approved by management. The organization has a clear and concise definition of the process used in all projects.
Level 4 - Managed	The active management of processes characterizes the Managed level. The organization monitors and controls its processes using quantitative methods. Processes are continuously improved and are routinely audited.
Level 5 – Optimized	The proactive management of processes characterizes the Optimizing level. The organization continually strives to improve its processes based on a quantitative understanding. The organization is constantly looking for ways to improve the efficiency and effectiveness of its software development processes.

Capacity Maturity Model Integration (CMMI)

CMMI is a framework devised by the Software Engineering Institute (SEI) at Carnegie Mellon University in the early 2000s, offering a structured approach to enhancing software engineering processes[22,23]. It outlines a five-level path for enhancing the processes incrementally (Table 5)[23]. The first three levels correspond to the capability levels of CMM, and the fourth and fifth levels represent advanced improvement[24]. CMMI has four main domains: process, project, engineering, and support, each further divided into sub-domains[22]. The process domain includes planning, resourcing, deploying, implementing, monitoring, controlling, apprising, measuring, and improving processes.

On the other hand, the project domain includes project design, development, and validation. In contrast, the engineering domain includes system and software engineering activities, spanning development and maintenance. Likewise, the support domain covers support product development and maintenance[24]. The CMMI model helps organizations improve their processes and expand their capabilities.

Table 5. Maturity Level of CMMI [22,23]

Steps	Detailed Description
Level 1 – Initial	This level is the starting point for an organization's journey toward process improvement. At this level, processes are

	typically ad-hoc and chaotic, with little management.
Level 2 – Managed	The processes at this level are beginning to be more controlled and managed. There is now some standardization and documentation of processes, and teams have started to track and monitor their work more systematically.
Level 3 – Defined	The use of formalized and standardized processes characterizes the Defined level. All processes are well-documented and approved by management. The organization has a clear and concise definition of the process used in all projects.
Level 4 - Quantitatively Managed	The processes are not only well-defined and standardized, but they are also quantitatively managed. This means that teams are monitored and controlled to ensure they follow the defined processes and that performances are measured and analyzed to identify areas for improvement.
Level 5 – Optimized	The processes are continuously improved. This means that performances are measured and analyzed to identify areas for improvement, with changes then made to the processes to improve them.

Electronic Medical Record Adaptation Model (EMRAM)

EMRAM, created by the Healthcare Information and Management Systems Society (HIMSS), offers a comprehensive framework for evaluating the maturity of electronic medical record (EMR) systems within healthcare institutions [25,26]. Comprising eight stages ranging from Pre-adoption to EMR optimization, the model delineates the evolution of EMR adoption and utilization (HIMSS). Developed in collaboration with clinicians and healthcare IT experts worldwide, EMRAM integrates seamlessly into clinical workflows. It facilitates comparative assessments of EMR progress across organizations. Consequently, it serves as a vital tool for healthcare entities to gauge and enhance their EMR implementation, ultimately elevating the standard of patient care.

Continuity of Care Maturity Model (CCMM)

CCMM is a powerful framework that helps healthcare organizations deliver seamless patient care across multiple care sites and providers[28]. Developed by HIMSS, CCMM builds on EMRAM, enhancing patient care by ensuring effective communication and teamwork among healthcare professionals. CCMM delegates responsibility for coordinated care to administrators/governance leadership, clinical leadership, and IT/technology leadership, enhancing interoperability, governance, workforce efficiency, and predictive analytics within digital health.[58].

CCMM comprises the five domains of governance, engagement, processes, information, and technology, each with several sub-domains that indicate the corresponding maturity level (Table 7). For instance, the governance domain includes organizational structure, policies and procedures, and risk management. In contrast, the engagement domain covers values, beliefs, communication, training, and education. The processes domain includes care coordination, care transitions, and disease management. In contrast, the information domain includes data collection, management, decision support, and reporting and analytics. The technology domain includes sub-domains for system architecture, security and privacy, and interoperability[59].

Table 7. The Maturity Stage of CCMM [25]

Steps	Detailed Description
Stage 0 - Limited or No E-Communication	At this stage, there is little to no electronic communication between care providers. This can make it challenging to coordinate care, as providers may not have access to critical patient information.
Stage 1 - Basic Peer-to-Peer Data Exchange	At this stage, care providers can exchange basic patient information electronically. This allows for better care coordination, as providers can access vital patient information more easily.
Stage 2 - Patient-Centered Clinical Data Using Basic System-to-System Exchange	At this stage, patient-centered clinical data is exchanged between care providers using basic system-to-system exchanges.
Stage 3 - Normalized Patient Record Using Structural Interoperability	At this stage, a normalized patient record is used to exchange patient information between care providers, allowing better care coordination.
Stage 4 - Care Coordination Based on Actionable Data Using a Semantic Interoperable Patient Record	At this stage, care coordination is based on actionable data using a semantically interoperable patient record where care providers can access essential information.
Stage 5 - Community-Wide Patient Records Using Applied Information with Patient Engagement Focus	Community-wide patient records are used at this stage to exchange patient information between care providers. This allows for better care coordination, as providers can access important patient information more easily.
Stage 6 - Closed Loop Care Coordination Across Care Team Members	At this stage, closed-loop care coordination is used to exchange patient information for better care coordination.
Stage 7 - Knowledge-Driven Engagement for Dynamic, Multi-Vendor, Multi-Organizational Interconnected Healthcare Delivery Model	At this stage, knowledge-driven engagement is used for dynamic, multi-vendor, multi-organizational interconnected healthcare delivery, and care providers access information.

Unlike EMRAM, which focuses on specific aspects of electronic medical records, CCMM takes a holistic approach to measuring maturity, emphasizing continuity of care and seamless patient information sharing among diverse care providers. Developed collaboratively by HIMSS and healthcare professionals worldwide, CCMM is a valuable tool for healthcare organizations to assess, implement, and scale coordinated care.

Clinical Digital Maturity Index (CDMI)

CDMI is a valuable tool introduced by the National Health Service (NHS) in 2013, and it was updated in 2016 to measure and track the progress of digital maturity within healthcare organizations in the United Kingdom[27]. It encompasses three key dimensions: capability, technological readiness, and infrastructure components. The capability dimension assesses whether an organization possesses a well-defined digitalization strategy, effective governance structures, and adequately trained staff. The technological readiness dimension assesses technology's availability, effectiveness, and adaptability to support digitization efforts. Meanwhile, the infrastructure dimension evaluates physical data and information management and the security infrastructure within the organization [27]. Each dimension of CDMI is further subdivided into fourteen sections, enabling a comprehensive assessment of an organization's digital maturity level. With CDMI,

organizations can identify their strengths and weaknesses in terms of digital readiness and devise strategic plans for improvement [59]. While the maturity model developed by HIMSS may not be directly applicable in the UK context, CDMI serves as a tailored and invaluable tool specifically designed for the UK market, offering a robust framework for assessing and advancing digital maturity within healthcare organizations. Furthermore, the framework facilitates monitoring progress and changes over time, fostering transparency and accountability (Table 8).

Table 8. Maturity Level of CDMI [27]

Steps	Detailed Description
Level 0 – Digital Maturity Self-Assessment	Organizations can assess their digital maturity using this tool. It is also possible to obtain independent assessments from an external organization to provide an objective view of an organization's digital maturity and guidance on how to improve its digital maturity.
Level 1 - Theme	Readiness, Capabilities, Infrastructure
Level 2-1 - Basic Digital Capabilities	Organizations typically have no formal processes for managing or improving their digital capabilities. They may have some digital capabilities but are not being used effectively or efficiently.
Level 2-2 - Developing Digital Capabilities	Organizations use digital technologies to improve patient care and clinical outcomes and develop digital capabilities.
Level 2-3 - Advanced Digital Capabilities	Advanced digital technologies are used to improve patient care, and organizations adopt these technologies to transform how they work.
Level 2-4 - Transforming Digital Capabilities	Organizations have formalized processes for transforming digital capabilities. They use data analytics to drive continuous improvements.
Level 2-5 - Standardizing Digital Capabilities	Organizations are utilizing digital technologies to standardize how they work and improve population health, which results in continuous improvements.

Interoperability Maturity Model (IMM)

IMM was developed by the National E-health Transition Authority of Australia (NEHTA) to aid healthcare organizations in evaluating their level of interoperability maturity. Primarily, IMM is structured around five stages of CMMI, accompanied by a set of interoperability goals and an evaluation model geared toward the national level[28]. These stages are intricately linked to organizational, informational, and technical dimensions at various levels, including local, corporate, and national scales. The model delineates interoperability targets to enhance scalability, scope, and configurability across these dimensions[29].

The organizational dimension addresses business and governance considerations, ensuring alignment with strategic objectives. The informational dimension focuses on data format and semantics, ownership and rights, and standard building blocks, facilitating effective data exchange. Meanwhile, the technical dimension encompasses specifications related to interface, functional decomposition, and communication protocols, which are vital for seamless interoperability. Although the IMM does not explicitly address architectural and technical policy separation, it furnishes healthcare organizations with a comprehensive framework to navigate their interoperability goals effectively [29]. By emphasizing these aspects, IMM enables the development of robust interoperability

strategies aligned with business objectives. Overall, it is a valuable tool for healthcare organizations to assess their interoperability maturity and devise plans for continuous improvement[60] (Table 9).

Table 9. Maturity Level of IMM [55]

Steps	Detailed Description
Level 1 – Initial	There is no interoperability.
Level 2 – Managed	The processes of this level are beginning to be more controlled and managed—a more customized approach aids in connecting technology to community specifications or standards.
Level 3 – Defined	Interoperability at the data-sharing level is characterized by documenting and formalizing technologies in the community.
Level 4 - Quantitively Managed	Interoperability at this process level and sharing lessons with other communities do not require customization, given the existing pre-established standardization.
Level 5 – Optimized	Purchasers of connected technology shall benefit from an improved interoperability performance language, and interoperability lessons will be implemented for continued improvements.

Telemedicine Service Maturity Model (TMSMM)

TMSMM is a comprehensive assessment tool designed to evaluate a telemedicine program's readiness to implement and sustain a successful telemedicine initiative [30]. Telemedicine practitioners developed it from five South African provincial health departments (DoH), focusing on various aspects of telemedicine application, particularly during the patient treatment stage[31]. This model encompasses five key characteristics: man, machine, material, method, and money, providing a holistic view of implementing a telemedical service. The assessment is conducted through micro and macro-level processes, with the maturity scale based on the generic-level indicators of CMM.

However, TMSMM consists of five levels, each representing a different stage of maturity in telemedicine service delivery. These stages are based on the program's ability to provide telemedicine services effectively and efficiently and its readiness to expand and sustain those services over time. The five levels are the initial stage, the experimental stage, the expansion stage, the consolidation stage, and the transformation stage. Beginning at the initial stage, telemedicine services are in their infancy phase, with limited reach. Progressing to the experimental stage, services are tested and evaluated for effectiveness[61]. In the expansion stage, services are scaled up, extending their reach to more patients and providers. Upon entering the consolidation stage, telemedicine services are fully integrated into the healthcare system. They are becoming an integral part of the healthcare delivery model. Finally, the transformation stage represents the highest level of maturity, where telemedicine services have transformed the healthcare system and have led to significant improvements in patient outcomes, provider efficiency, and cost savings (Table 10).

Table 10. Maturity Level of TMSMM [30,56].

Steps	Detailed Description
Level 1 – Initial / Ad Hoc	Telemedicine is used as needed, but no formal structure or governance is in place.
Level 2 – Managed	Telemedicine is used regularly, and some formal structures and governance are in place.

Level 3 – Standard	Telemedicine is integrated into the healthcare delivery system, with strong stakeholder coordination.
Level 4 - Quantitively Managed	Telemedicine Services have well-defined and managed processes in place. Processes are monitored, controlled, and continuously improved.
Level 5 – Optimized	Optimization is in place, and the telemedicine service is continuously monitored and improved. The goal is to achieve the highest level of efficiency and effectiveness possible.

Social Media Customer Care Model

In 2011, Cisco developed the social media customer care model to facilitate customer support via social media platforms such as Twitter, Facebook, and Instagram for business[32]. However, this model did not specifically cater to the healthcare industry. Researchers have developed a new social media maturity model tailored to address this gap for healthcare organizations. This model delineates various social media adoption and implementation stages within the healthcare industry[32]. The novel model holds significant importance for the healthcare industry, enabling organizations to effectively leverage E-health and Health 2.0 strategies to enhance customer service and ensure optimal patient care. By embracing this model, healthcare institutions can refine their social media strategies, advancing their use of these platforms and ultimately elevating patient satisfaction and care quality (Table 11).

Table 11. Maturity Level of the Social Media Customer Care Model [32]

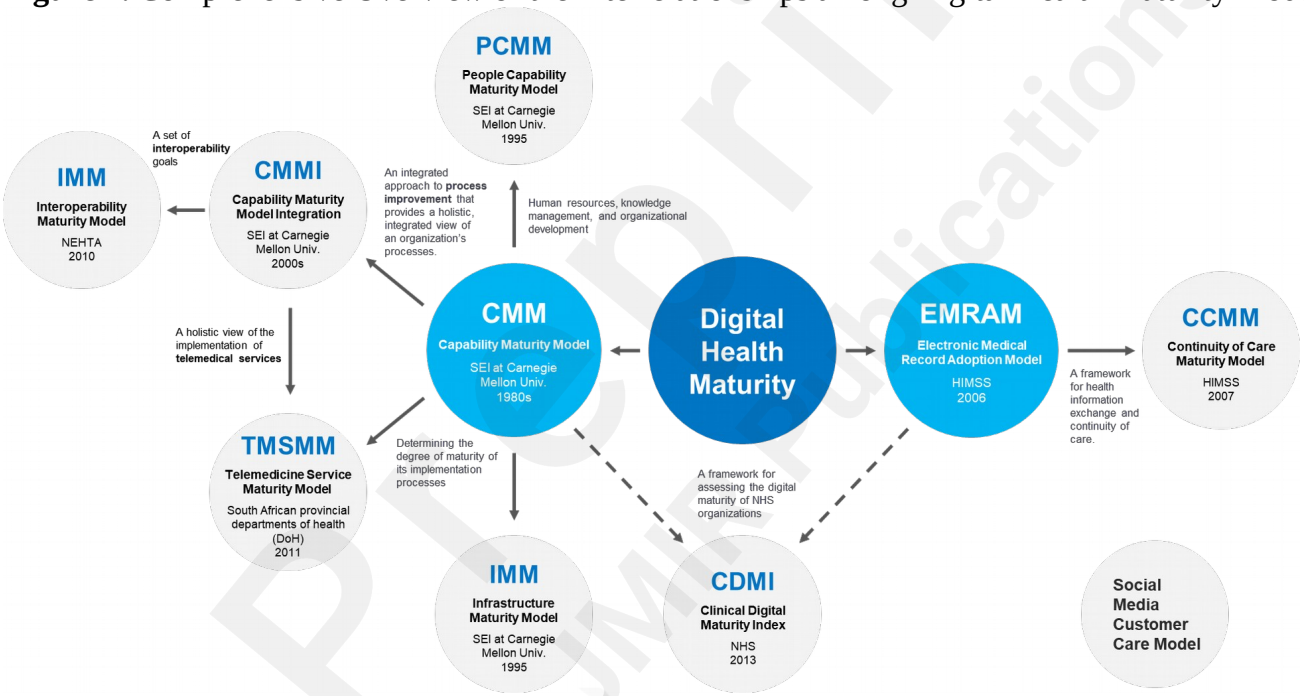
Steps	Detailed Description
Level 1 – Listening (or Ignoring)	This is the most fundamental level of social media customer service, which entails monitoring the brand online and responding as needed. This can be carried out manually or with the aid of automated tools.
Level 2 – Social Media Broadcasting	At this stage, businesses use social media as a one-way channel to broadcast messages to their target audience, including their customers. This stage includes company-related announcements, promotions, and other information.
Level 3 – Social Media Marketing	This level enhances social media customer service with a more interactive component to engage customers and foster relationships. It entails responding to customer inquiries, hosting chat sessions, or conducting social media campaigns.
Level 4 – Social Media Customer Care	This is the highest social media customer service level, including using social media as a comprehensive platform. Providing customer assistance, responding to complaints, and processing exchanges and refunds are included.

Level 5 – Proactive Engagement	Using social media to reach out to customers and build relationships proactively is the pinnacle of social media customer care. This stage includes sending personalized messages to recipients, offering deals unavailable to the general public, and hosting events. The organization has a formal social media customer care strategy to engage with customers proactively.

Unveiling the relationship of Maturity Models in Digital Health

A comprehensive review of maturity models revealed that CMMI, IMM, CDMI, TMSMM, and PCMM were all developed to enhance CMM, which forms the basis of the development of two additional models: the People Capability Maturity Model (PCMM) and the Infrastructure Maturity Model. This expansion offers a more holistic approach to process improvement that encompasses managing people, processes, and technology (Figure 2).

Figure 2. Comprehensive Overview of the Interrelationships among Digital Health Maturity Models



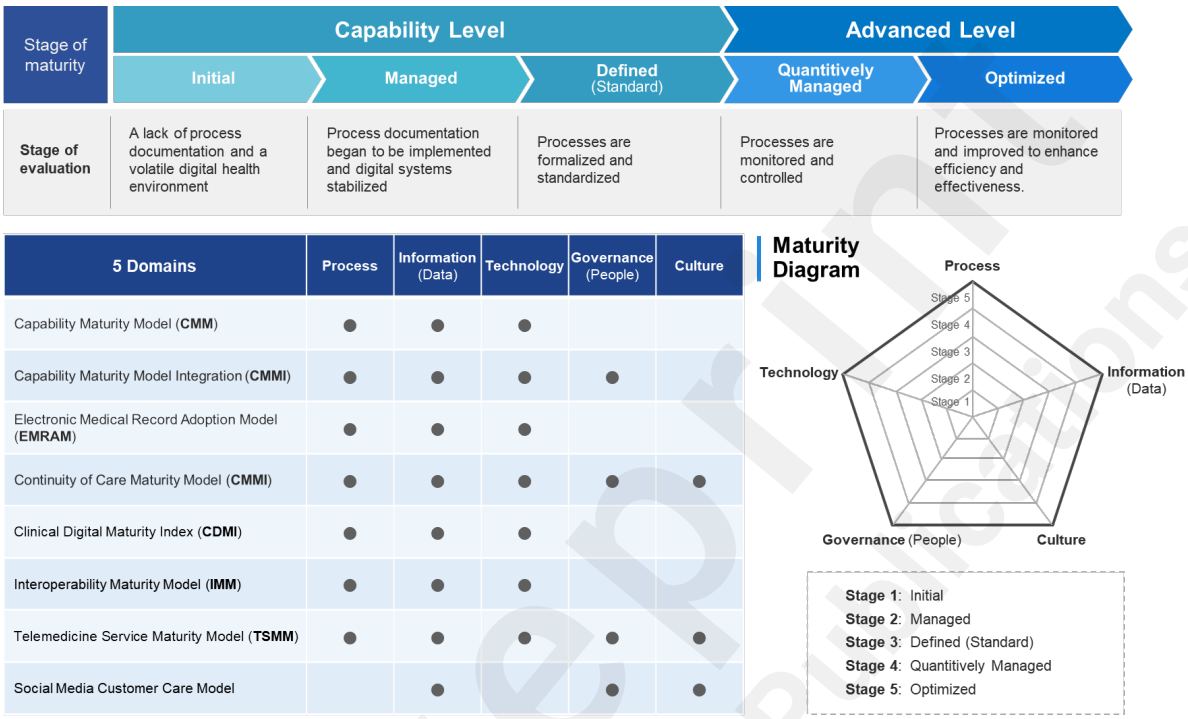
While CMM was not initially designed for digital health, EMRAM has emerged as the second most widely utilized maturity model because it enables maturity assessments of Electronic Medical Records (EMRs), which form the core of digital health. Additionally, CCMM was designed to facilitate the seamless sharing of health information among various healthcare stakeholders to ensure continuity of care. Similarly, the social media customer care model was created to engage patients within the digital health platform.

However, existing maturity models provide only a broad overview of the evolving digital health system. They are, thus, insufficient for determining the level of maturity. Their focus on broader aspects of process improvement limits their effectiveness in comprehensively measuring digital health system maturity [62]. Therefore, there is a pressing need for further advancement and refinement of maturity models to ensure their continued relevance and efficacy in supporting the digital transformation of the healthcare industry.

Analyzing Eight DHMM's Maturity Levels and Domains to Assess Digital Health

Table 12 provides an overview of the components and shared elements of the eight maturity models, highlighting their differences and scope. Meanwhile, the five maturity levels in these models, referred to here as the initial managed, defined, qualitatively managed, and optimized (Figure 3).

Figure 3. Comprehensive Overview of Existing Digital Health Maturity Models: Level of Maturity and Domain



The first three levels are capability stages focused on developing the capabilities of the digital health system. The other two levels are advanced stages focused on utilizing basic capabilities. Each model's domains can be separated into five categories: Process, Information, Technology, Governance, and Engagement. These domains help to measure the organization's execution of strategies, processes, and initiatives.

Table 12. Overview of 8 Essential Maturity Models in Digital Health

Name of Model / Developer	Character	Domain	Level of Process Maturity
Capability Maturity Model (CMM) / Carnegie Mellon University (1980s)	A process improvement model that provides a framework for improving the quality of software development process	1. Process improvement	1. Initial 2. Repeatable 3. Defined 4. Managed 5. Optimized
Capacity Maturity Model Integration (CMMI) / Carnegie Mellon University (2000s)	A process improvement approach that provides a framework for organizations to improve their processes	1. Process 2. Project 3. Engineering 4. Support	1. Initial 2. Managed 3. Defined 4. Quantitatively Managed 5. Optimized

Electronic Medical Record Adaptation Model (EMRAM) / Healthcare Information and Management Systems Society (2006)	A framework for the implementation and use of electronic medical records (EMRs) in healthcare organizations	1. EMR adoption 2. EMR use 3. EMR data 4. EMR workflow 5. EMR decision support 6. EMR reporting 7. EMR optimization	1. No EMR system in place 2. EMR Adoption-Incomplete 3. EMR Adoption-Partial 4. EMR Adoption-Complete 5. EMR Optimization-Incomplete 6. EMR Optimization-Partial 7. EMR Optimization-Complete 8. Complete EMR; External HIE; Data Analytics, Governance, Disaster Recovery, Privacy and Security
Continuity of Care Maturity Model (CCMM) / Healthcare Information and Management Systems Society (2007 and updated in 2012 and 2017)	A framework for measuring the maturity of an organization's continuity of care processes.	1. Governance 2. Engagement 3. Processes 4. Information 5. Technology	1. Limited or No E-Communication 2. Basic Peer-to-Peer Data Exchange 3. Patient-Centered Clinical Data using Basic System-to-System Exchange 4. Normalized Patient Record Using Structural Interoperability 5. Care Coordination Based on Actionable Data Using a Semantic Interoperable Patient Record 6. Community-Wide

			Patient Records Using Applied Information with Patient Engagement Focus 7. Closed Loop Care Coordination 8. Knowledge-Driven Engagement for Dynamic, Multi-Vendor, Multi-Organizational Interconnected Healthcare Delivery Model
Clinical Digital Maturity Index (CDMI) / United Kingdom National Health Service (2013 & updated in 2016)	Measurement of the digital maturity of NHS organizations	1. Capability 2. Technological readiness 3. Infrastructure components	1. Digital Maturity Self-Assessment 2. Readiness, Capabilities, Infrastructure 3. Questions
Interoperability Maturity Model. (IMM) / National E-health Transition Authority of Australia (2010)	Interoperability is associated with the technical, informational, and organizational capacities of the different players involved in health services.	1. Data 2. Process 3. People 4. Technology	1. Initial 2. Managed 3. Defined 4. Quantitively Managed 5. Optimized
Telemedicine Service Maturity Model (TMSMM) / South African provincial departments of health (2011)	A tool used to assess the readiness of a telemedicine program to implement and sustain a successful telemedicine initiative	1. Management 2. Machine 3. Material 4. Method 5. Money	1. Initial/Ad Hoc 2. Managed 3. Standard 4. Quantitatively managed 5. Optimized
Social Media Customer Care Model / Cisco (2011)	A framework that businesses can use to measure their social media maturity and	1. Social media presence 2. Knowledge of engagement with the	1. Listening and Learning 2. Social Media Broadcasting 3. Social Media

	progress over time	audience 3. Connection to a strategy 4. Corresponding monitoring and metrics (business intelligence) 5. Integration with processes	Marketing 4. Social Media Customer Care 5. Proactive Engagement

Based on a comprehensive review of this repository, insights into the detailed mechanisms of DHMM functionality are provided in response to the second research question. This involved aggregating information from diverse studies and models that rely on institutions such as HIMSS and WHO as their sources, providing a clearer understanding of the key attributes of digital health maturity assessment. Additionally, this review provides knowledge about how DHMMs have seemingly overlooked technologies, organizations, and societal issues. We also shed light on areas such as cyber security, governance structure development, the social determinants of health, and change management, which existing models overlook.

It is necessary to establish process documentation and digital systems stabilization at the initial level, followed by the Managed level, which formalizes and standardizes the process. Subsequently, the Quantitatively Managed level enables monitoring and control of standardized processes. In contrast, the Optimized level involves active monitoring and enhancing the process to maximize efficiency and effectiveness. The domains in each model have distinct categories. However, they can be separated into five categories, each critical for digital health maturity. Governance is essential to digital health maturity because collaborative agreements between stakeholders, legal frameworks, and regulations must be established as new processes emerge.

However, only four of the eight existing models address the aspect of governance. Engagement domain components focus on the interaction between people and the degree of community involvement, with only three focusing on this domain. This research indicates that existing maturity models in digital health lack comprehensive coverage of critical aspects such as governance and engagement, which are essential for assessing maturity levels effectively. Therefore, developing a new integrated model is necessary to close these gaps and provide a more accurate digital health system maturity assessment.

Discussion

The systematic evaluation is intended to represent the current state of DHMMs, as is typically done in similar evaluations. Through screening 29 studies in well-known databases such as PubMed, EBSCO, and ProQuest, it is proven that the communicative factor does not have the same weight as the infrastructural weight in existing healthcare delivery models and that the current digital aspect is important[18]. The challenging complexity of comprehensive assessment of digital health maturity

levels relative to user satisfaction, engagement, personalization, and customization is presented.

Principal Results

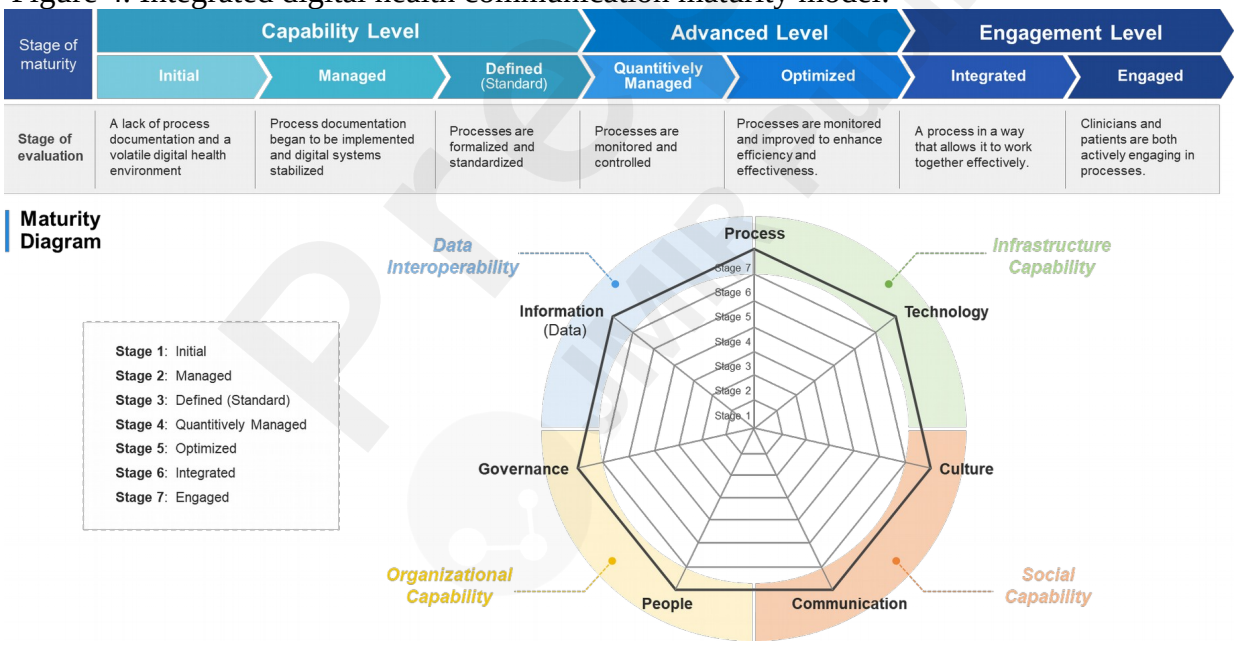
Incorporating Communication Elements in DHMMs

Digital communication components within the DHMM framework are crucial in completing assessments. Unlike traditional DHMMs focused on technical features, communication dimensions practically include user connectivity, acceptance, personalization, and customization, which are critical factors in platforms of digital health[62]. These elements can give DHMMs a coherent approach to evaluating a digital health management organization. They capture technical capabilities and examine the quality of patients' and stakeholders' interaction and communication experiences. This integration can uncover the benefits of digital health methods and progress regarding needs[63]. The process lays the groundwork for digital health projects to align with users' needs and preferences, leading to more efficient and popular digital health solutions.

Introducing the Digital Health Communication Maturity Model

The Digital Health Communication Maturity Model DHCMM, a paradigm for evaluating digital health maturity. DHCMM has a vital feature unique to the other DHMMs that tend to prevail over the communication dimensions[56]. It includes specific centric metrics, specifically satisfaction, engagement, personalization, and customization, in its framework (Figure 4).

Figure 4. Integrated digital health communication maturity model.



Therefore, DHCMM is ultimately the key to assessing an organization's readiness and capabilities for successfully implementing its digital health communication strategies[44]. By blending in communication models, the framework provides a more comprehensive take on the relationships among the patients, digital health tools, and the medium of communications, covering the aspect of channels, messaging, and the user experience[45].

The core idea of DHCMM is the two-sided requirement to have effective communication as an enabler of the technology and as the primary source of success in the digital health initiative[46]. Hence, the influence of communication strategies should be custom-tailored to suit different user

profiles as a varied population's specific needs and preferences grow[47].

The versatility of DHCMM across various health environments and contexts is one of its key attributes, setting it apart from traditional healthcare procedures. From private clinics to public health campaigns and consumer-facing digital healthcare platforms, the model serves as a structured approach, discerning communication effectiveness and highlighting inadequate areas[63].

In other words, DHCMM is a product of the latest digital technology development. Its introduction in digital health evaluation represents major progress, as it offers a robust framework for assessing and improving communication practices in the digital age[46]. By instilling collaboration, governance, and meaningful engagements with e-health applications, the model offers paths to more efficient and user-centered digital health development.

Enhancing Assessment and Optimization

Effective communication is crucial for the success of digital health initiatives, irrespective of the technological infrastructure[14]. Conversely, social factors such as user experience and communication significantly influence the acceptance and utilization of digital health solutions. Thus, overlooking these social capability aspects during digital health maturity assessments can undermine even the most advanced technological implementations[15]. In response to this dynamic nature of digital health, this review introduces DHCMM, which addresses the limitations of existing DHMMs. The proposed model integrates DHMMs, communication, engagement factors, and technological dimensions, offering a precise roadmap and addressing crucial gaps to provide a nuanced view of an organization's digital health maturity in the complex digital health landscape.

It is known that the current DHMM version primarily focuses on stabilizing the digital health system. However, it is imperative to incorporate bi-directional aspects such as CCMM and the social media customer care model to enhance user engagement at the community level. Such additions are expected to improve the operationalization of the digital health ecosystem, from the hospital to community care. In relation to this, an expanded maturity model, as depicted in Figure 4, introduces an engaged stage alongside the capability and advanced stages.

Level 6, the integrated level, emphasizes coordinated data and governance procedures, actively involving healthcare professionals, patients, and community members. Level 7, the engaged level, underscores the importance of the active involvement of organizations, community members, and physicians throughout the healthcare system.

A seven-level framework can be employed to conceptualize digital health systems. The first three levels, Initial, Managed, and Defined (Standard), constitute the Capability stage. Qualitatively Managed and Optimized levels form the advanced stage. The Integrated and Engaged levels emphasize active user engagement and provide a platform for the active interchange of information while developing digital health capabilities in recently adopted areas and focusing on the effective use of advanced capabilities.

Overall, the proposed Integrated Digital Health Communication Maturity Model offers a more comprehensive approach to measuring the maturity of digital health systems, incorporating communication and engagement aspects previously absent in the DHMM case. This model provides a framework for actively engaging users and stakeholders in the digital health ecosystem, emphasizing the importance of collaboration, governance, and the effective use of digital health capabilities.

The Seven Domains of Maturity for Optimal Outcomes

DHCMM offers a comprehensive approach to evaluating digital health systems,

incorporating crucial communication and engagement aspects previously overlooked by DHMMs. This model emphasizes collaboration, governance, and the effective use of digital health capabilities to engage users and stakeholders in the digital health ecosystem actively.

The seven crucial domains of maturity, Process, Information (or Data), Technology, Governance, Management, Engagement, and Communication collectively contribute to ensuring optimal outcomes in digital health systems. The Process and Technology domains focus on ensuring the infrastructure to support digital health initiatives. Governance and Management are essential in efficiently applying digital health technology, encompassing organization-wide strategy, decision-making, and process management standards. Accordingly, the Engagement and Communication domains highlight the significance of social capabilities in successful digital health implementation. Engagement involves adapting to process changes, values, beliefs, attitudes, and behaviors. At the same time, Communication emphasizes effective communication and cooperation within the process management framework.

The Integrated Digital Health Communication Maturity Model offers a comprehensive digital health system maturity assessment encompassing all relevant domains. Through its thorough coverage of these domains, the model ensures that systems are finely tuned for success, emphasizing user engagement and personalized care.

Evaluating Stakeholder Alignment

The effective execution of digital health programs hinges on collaborating with various stakeholders, including patients, legislators, healthcare professionals, and technology developers. While DHMMs have achieved significant progress in evaluating technology capabilities, the integrated DHCMM critically emphasizes stakeholder alignment. Efficient communication and cooperation among different groups are vital for aligning stakeholders ensuring that the digital health ecosystem meets the requirements and expectations of all stakeholders. DHCMM acknowledges the importance of this alignment within its Governance and Engagement domains. Governance establishes the legal frameworks and collaborative agreements, creating an environment conducive to digital health initiatives. It ensures that policies and regulations evolve alongside emerging technologies[14].

Moreover, the Engagement domain of DHCMM underscores the importance of community involvement, user interaction, and effective communication techniques. Unlike traditional DHMMs focusing solely on technology infrastructure, DHCMM acknowledges the broader scope of digital health maturity, considering the social aspects involved. It emphasizes active engagement from patients, healthcare professionals, and communities, recognizing their significant role in the success of digital health initiatives. The stakeholder-centric strategy of DHCMM bridges the communication gap among important actors to achieve optimal outcomes. Likewise, technological proficiency calls for recognizing and addressing stakeholders' various requirements, values, and beliefs [15]. This concept compels enterprises to consider the human factor in digital health, understanding that successful adoption requires more than cutting-edge technology.

Driving the Effective Use of Digital Health Capabilities

Furthermore, the Integrated DHCMM expands on the topic beyond technology by emphasizing the role of stakeholder alignment in achieving digital health maturity. Through its assessment of the efficacy of communication, engagement, and governance framework, the model offers an all-inclusive roadmap for businesses to traverse the intricacies of the digital health terrain. While digital health technologies have revolutionized healthcare by improving communication and patient care, the absence of a standardized measure for digital health maturity presents a significant challenge. While existing maturity models are outlined in this review, a further, more detailed

analysis is warranted.

The DHCMM also stresses the significance of persistent monitoring and evaluation in achieving progress in digital health communication strategies and battling misinformation. By latching onto key performance indicators and altering the approaches, organizations can tweak the utilization of their digital health capabilities and eventually improve the overall effect on healthcare outcomes.

Limitations

While DHCMM presents a forward-looking approach to integrating digital technologies in health communication, its practical application is fettered by significant limitations. One crucial concern is its potential lack of generalizability across various healthcare settings and populations. Health communication needs and effectiveness can vary dramatically among different demographic groups and medical environments. DHCMM may not uniformly apply to all cases, particularly in unique or 'corner case' scenarios, where its efficacy may differ. This variability can lead to uneven benefits of the model, with some populations or settings deriving more value than others. Nonetheless, it represents an advance that warrants widespread use.

DHCMM will be at the forefront of the future as technology evolves with the advancements in digital health and communication techniques. The next step in the evolution is integrating artificial intelligence and machine learning algorithms while personalizing the communication strategy to the individual. Using data analytics and predictive modeling, DHCMM can assist organizations in their efforts to frame communication messages in tandem with individual tastes and actions, meaning that it will increase involvement and effectiveness. Concerns emerge about closing the digital gap in access to digital health equipment, communication technologies, and equitable resources for all[70]. Additionally, as digital health is spreading worldwide, it will become feasible for DHCMM to be used in different cultural spaces among various nations, which will most likely result in cross-border collaborations and knowledge exchanges.

Conflicts of Interest

None declared.

Abbreviations

CMM – capability maturity model
CMMI – capacity maturity model integration
CCMM – continuity of care maturity model
CDMI – clinical digital maturity index
DHCMM – digital health communication maturity model
DHMM – digital health maturity model
EMR – electronic medical record
EMRAM – electronic medical record adaptation model
HIE – health information exchange
HIMSS – healthcare information and management systems society
IMM – interoperability maturity model
NHS – national health service
PRISMA – preferred reporting items for systematic reviews and meta-analyses
SCIROCCO – scaling integrated care in context
SORMAS – surveillance outbreak response management and analysis system
TMSMM – telemedicine service maturity model

Multimedia Appendix 1

Multimedia appendices are supplementary files, such as a PowerPoint presentation of a conference talk about the study, additional screenshots of a website, mpeg/Quicktime video/audio files, Excel/Access/SAS/SPSS files containing original data (very long tables), and questionnaires. See https://jmir.zendesk.com/hc/en-us/articles/115003396688 for further information. Do not include copyrighted material unless you obtained written permission from the copyright holder, which should be uploaded together with your Publication Agreement form as supplementary file.

The Multimedia Appendices must be uploaded online, accompanied by a caption. CONSORT-EHEALTH checklists are always uploaded as Multimedia Appendices. Although this is primarily intended for randomized trials, the section of the checklist describing how an intervention should be reported is also relevant for manuscripts with other evaluation designs.

Before submission, authors of RCTs must **fill in the electronic CONSORT-EHEALTH questionnaire at http://tinyurl.com/consort-ehealth-v1-6** with quotes from their manuscript (if you wish to comment on the importance of the items from the checklist for reporting, please also rate each item on a scale between 1-5). BEFORE you press submit, please generate a pdf of the form with your responses and upload this file as supplementary file entitled CONSORT-EHEALTH V1.6.

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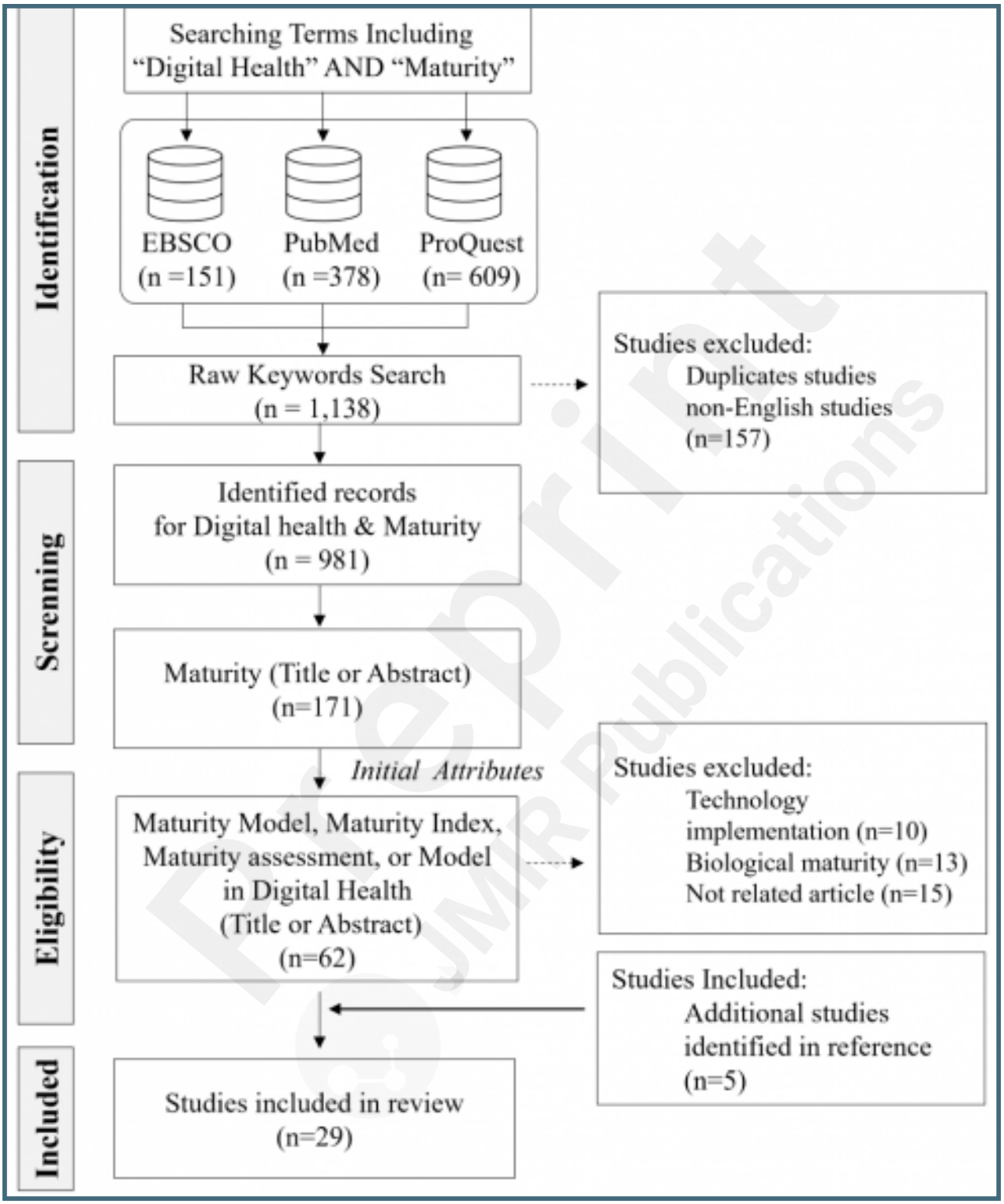
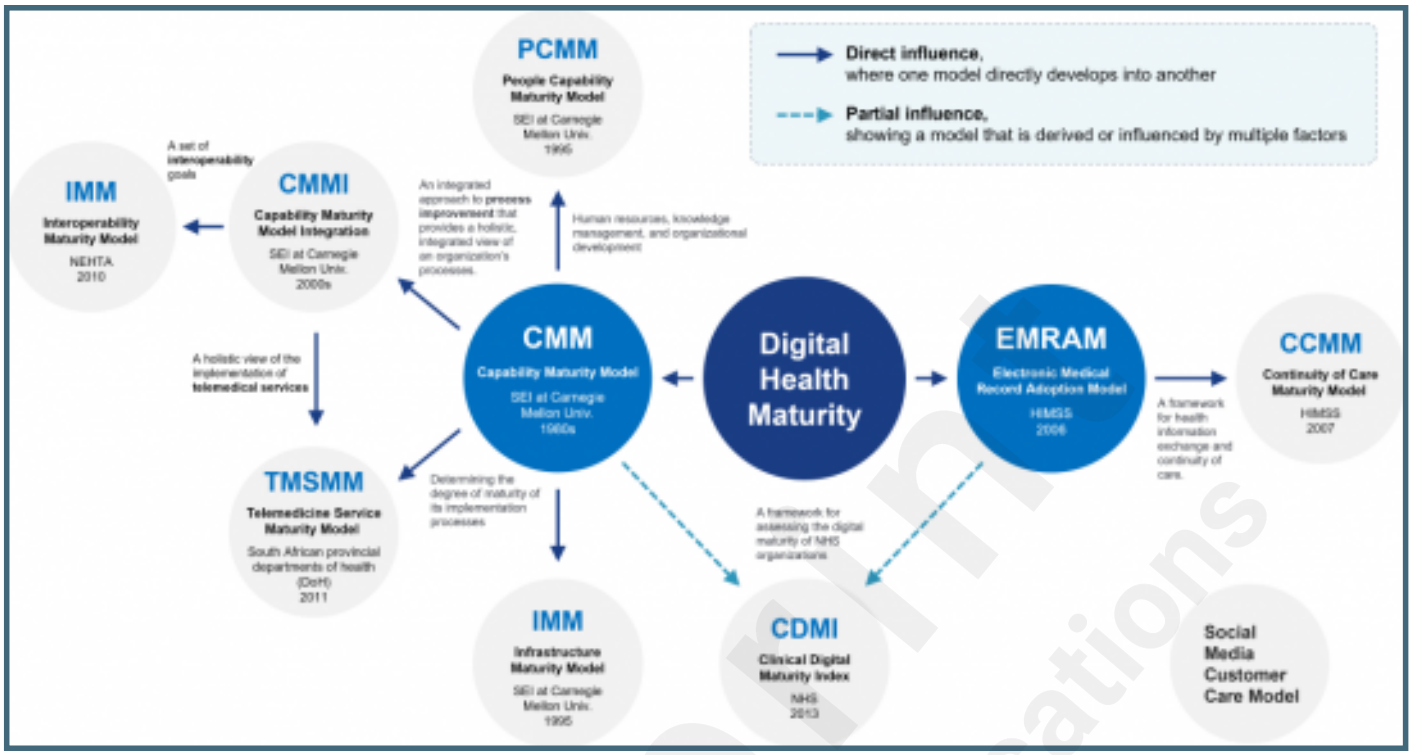
Supplementary Files

Figures

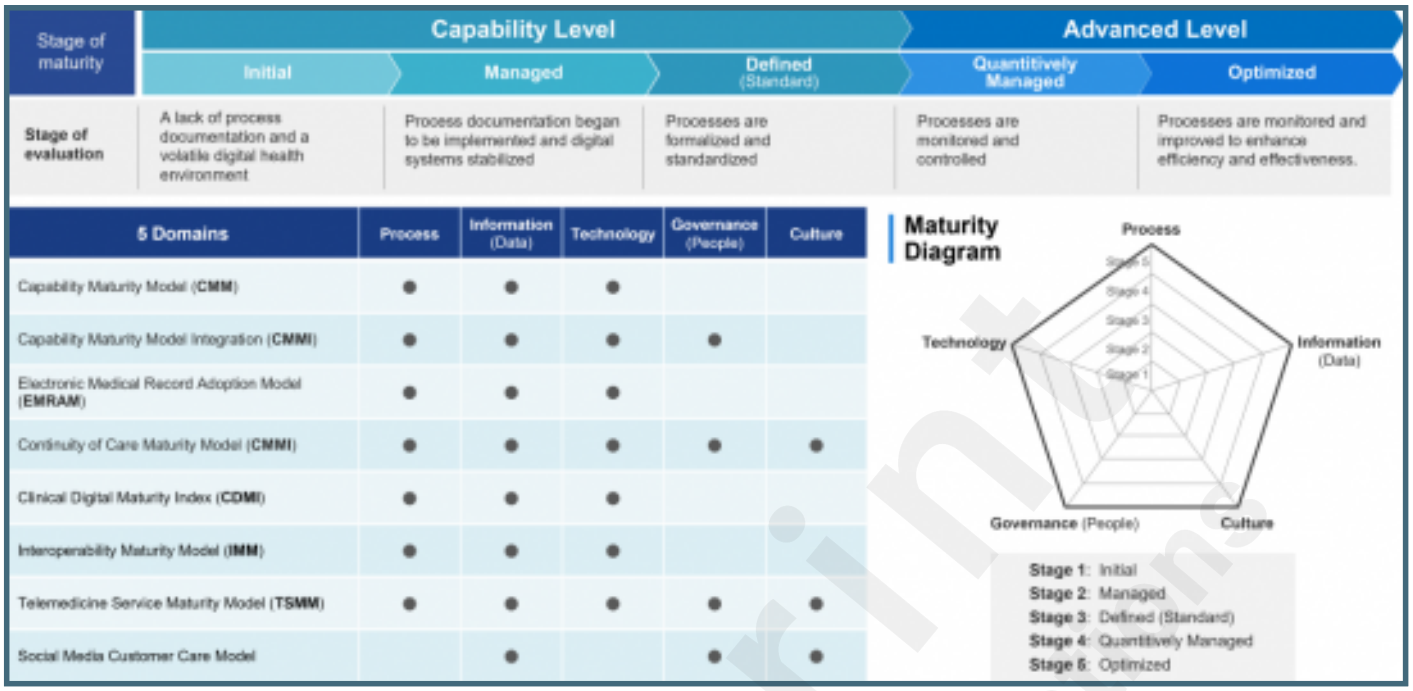
Screening process through the PRISMA-based flowchart.



Comprehensive Overview of the Interrelationships among Digital Health Maturity Models.



Comprehensive Overview of Existing Digital Health Maturity Models: Level of Maturity and Domain.



Integrated digital health communication maturity model.