Maturity Models of Healthcare Information Systems and Technologies: a Literature Review

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Abstract The maturity models are instruments to facilitate organizational management, including the management of its information systems function. These instruments are used also in hospitals. The objective of this article is to identify and compare the maturity models for management of information systems and technologies (IST) in healthcare. For each maturity model, it is identified the methodology of development and validation, as well as the scope, stages and their characteristics by dimensions or influence factors. This study resulted in the need to develop a maturity model based on a holistic approach. It will include a comprehensive set of influencing factors to reach all areas and subsystems of health care organizations.

This article is part of the Topical Collection on *Systems-Level Quality Improvement*

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Introduction

Health institutions together with government organizations are realizing that a certain inability to properly manage the processes of health is directly related to technological infrastructure limitations and management inefficiency [1, 2]. Hospital Information systems managers usually look at the mistakes made in these organizations and ask themselves on what they should have done to prevent them. It appears that these errors are usually symptoms of natural growth and organizations maturation. It seems to be the result of the development of the organization to its current maturity [3, 4]. The changes that an organization experiences, from its beginning to maturity, fit perfectly into the principles of Stages of Growth theory. Also, they occur in the current context of healthcare IST.

The maturity models are based on the premise that people, organizations, functional areas, processes, etc., evolve through a process of development and growth towards a more advanced maturity accomplishing several stages [5].

Mutafelija and Stromberg [6] reports that the concept of maturity has been applied to more than 150 areas of IST. Obviously, the maturity models have also been applied in various fields of IST in the health field.

This article first presents a brief overview of the Maturity Models in IS area (second section). Then in third section, the research methodology adopted in literature review is described. Fourth section presents the results of the literature review, that is, the 14 Maturity Models of IST in health care are described. Finally, in fifth section is presented the summary and closing remarks.

Maturity models in IST management

Richard Nolan is considered the principal architect of the IST maturity approach. In fact, after studying the use of IS in major organizations in US, Nolan proposed a four stages maturity model [7]. Later, he improved the first version adding two new stages to the initial model [8]. In this second version, the model states that organizations begin slowly in the *Initiation* stage, which is followed by a period of rapid spread of the use of IT in *Contagion* stage. Later, the need for *Control* arises. Then, it is followed by *Integration* of different technological solutions. The *Data Administration* stimulates development with no costs increasing associated with IST. Finally, steady growth produces *Maturity.*

While this approach to Nolan maturity models has been recognized as highly innovative, it also has generated discussion and controversy. Some researchers have validated the model but others have suggested additions. Another researchers have developed new models (e.g. [9–13]).

Among the new models after the Nolan first version model, the most consensual, comprehensive and understanding is the Galliers and Sutherland Revised Model [4, 5]. This model provides a better view of how an organization plans, develops, uses and organizes an IS and provides suggestions for progression toward higher maturity stages. This method consists of six stages. It assumes that an organization can stand in different stages of maturity at any time and can be conditioned by different factors of influence. Besides, it has features matching modern network organizations and provides a data collection tool to assess the maturity [5]. Recently, after the Galliers and Sutherland [13] model, other models have been proposed (e.g. [14–17]), including a new model of Nolan with nine maturity stages [18] to meet technological developments of IST and its management. With regard to IS management, another good example of maturity model is Khandelwal and Ferguson model [15] which features nine stages of maturity. It combines the theory of stages with critical success factors. Nevertheless, the Galliers and Sutherland [13] continues to be considered the most complete and updated IST management model [3, 4].

The maturity models are applied in one department alone or in the whole organization. They fit in various types of organizations. In fact, there are several examples of maturity models focused on different areas of the organization and IST: Damsgaard and Scheepers [19] maturity model for Intranets, Holland and Light [20] maturity model for ERP systems, CMMI [21] maturity model and ISO / IEC 15504 [22] for software development processes. There are also maturity models in the areas of software maintenance [23], business management [24], project management ([25, 26]), project management for portfolios and programs [27], information management [28], management of IS/ICT [29], e-business [12, 30–32], e-learning [33], knowledge management [34, 35], business process management (BPM) [36], enterprise architecture [37, 38], etc.
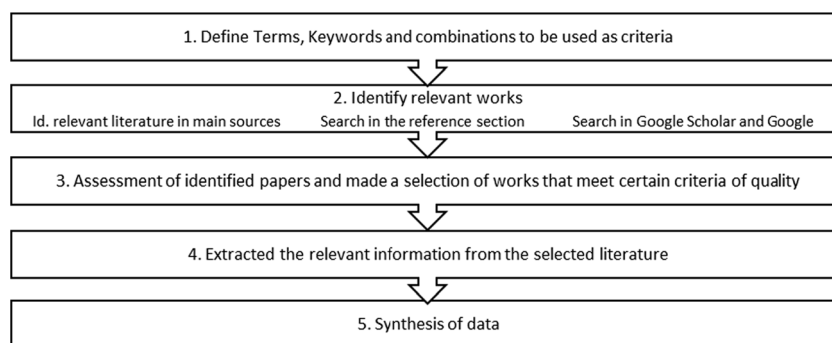
Methodology adopted for the literature review

Aiming to conduct a comprehensive and wide literature review, it was necessary to define a strategy in order to identify and analyze systematically the available literature on maturity models of healthcare IST. An initial review provided criteria to choose the approach and establish the strategies to be applied to this project.

The first strategy by Webster and Watson [39] suggests a structured approach in three basic steps: to identify the relevant literature in main sources (i.e. "leading journals") and recognized conferences. Then, the authors suggest conducting a search in the reference section of the studies identified in the first step in order to identify potential works related; finally, it is suggested the search via Web of Science of works which cite the works identified in the previous two steps.

The second strategy, proposed by Tranfield et al. [40], suggests five steps for a systematic review of the literature. The first stage defines terms, keywords and combinations to be used as criteria to be applied in the literature review. A second phase is to identify relevant works that contain the keywords and terms defined above. In the third phase, it is carried out an assessment of identified papers and made a selection of works that meet certain criteria of quality. In the fourth phase, it must be extracted the relevant information from the selected literature. Finally, in the fifth phase a synthesis of data is done.

The analysis of both strategies described above shown that the approach of Webster and Watson [39], although simple and easy to implement, is not completely suited to this work. The literature on maturity models of healthcare information systems is limited in major journals and conferences. With regard to Tranfield et al. [40] approach, it was found that there is not a clear procedure for the identification of relevant work in the second phase. On the other hand, when assessing the quality of studies, the authors state that it is a challenge to define quality criteria for qualitative work. It caused some apprehension due to the fact that most of the work in this area has a qualitative approach. Despite the concerns referred above, the literature review was carried out based on this approach with minor modifications and simplifications (Fig. 1). The second phase of Tranfield et al. [40] was replaced by the three basic steps described by Webster and Watson [39].

Therefore, the terms and keywords were defined as literature searching criteria, taking in account that most of the relevant literature on maturity models of health care information systems is written in English. "Maturity Model" and "Stages of Growth" combined with other terms of this knowledge area were used for the search iterations (Table 1).

Fig. 1 Methodology adopted for the systematic literature review


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│ 1. Define Terms, Keywords and combinations to be used as criteria      │
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│ 2. Identify relevant works                                             │
│ Id. relevant literature in main sources   Search in the reference section   Search in Google Scholar and Google │
└─────────────────────────────────────────────────────────────────────┘
┌─────────────────────────────────────────────────────────────────────┐
│ 3. Assessment of identified papers and made a selection of works that meet certain criteria of quality │
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│ 4. Extracted the relevant information from the selected literature     │
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│ 5. Synthesis of data                                                   │
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The searching criteria were applied to the literature review. Given that Tranfield et al. [40] did not suggest any procedure for this stage, it was followed the approach proposed by Webster and Watson [39] introducing two changes: in the first step, the main sources were replaced by major web platforms of scientific literature; and in the third step of this approach, Web of Science platform was replaced by the search engines Google and Google Scholar.

Then, we look for research works across the platforms AIS Electronic Library, ISI Web of Knowledge, SCOPUS, Springer, Elsevier/Science Direct and IEEE Computer Society Digital Library. Afterwards, we proceeded to a data analysis to identify related references, as suggested by Webster and Watson [39]. Finally, given that the disclosure of much of the information on Maturity Models of health care information systems has been accomplished through technical reports, research and white papers projects, we move to a more extended search through the search engine Google Scholar and Google to ensure identification of other relevant work for the study. It should be noted that our study found that research on overall maturity models is in increasing, however, much of the publishing related to health care are not present in the IST leading journals.

After identifying a wide range of work in this area, according to the approach of Tranfield et al. [40] it was necessary to define quality criteria for the selection of suitable studies for this research. However, despite the difficulty in defining quality criteria for qualitative work, it was found that few models presented details of their design process and decisions taken in its development [41]. It was understood that it was convenient to apply a simple and comprehensive criterion of quality. It was established to gather all the studies when it was possible to clearly identify the context (motivation, goal, results, and benefit) and where maturity models were mentioned directly or indirectly. The characterization of each model was done taking in account description, scope, identification of stages and their characteristics, size, influencing factors, methods adopted in the development and validation process.

In the end, after processing of all cases, to some extent conditioned by the perception of researcher on maturity models in the IST health field, we selected 14 models which are described below.

Maturity models of IST in health care

The maturity models identified in the literature review as the most relevants are the Quintegra Maturity Model for electronic Healthcare [2] and the Healthcare IT (HIT) Maturity Model developed by IDC Health Industry Insights. They present a wide scope on Hospital IST [42].

The HIMSS Maturity Model for Electronic Medical Record [43] and the Continuity of Care Maturity Model [44] are examples of applications for the Electronic Medical Record (EMR). Both were developed by the same HIMSS. Besides, there is the maturity model for Electronic Patient Record (EPR) [45] for systems that manage all patient information and Patient Records/Content Management Maturity Model [46].

Also, there are national health services that have begun to develop and adopt maturity models for the health area. For example, the National E-health Transition Authority of Australia [47] has created the Interoperability Maturity Model. This model was designed for interoperability associated with the technical, informational and organizational capacities of the different players involved in health services. Another example is the NHS Infrastructure Maturity Model [48]. It is a maturity assessment model that helps organizations of the United Kingdom National Health Service to conduct self-assessment of their technological infrastructure.

Table 1 Research criteria for the systematic literature review

Research criteria
"Maturity Model" AND "Health"
"Maturity Model" AND "Healthcare"
"Maturity Model" AND "Hospital"
"Maturity Model" AND "eHealth"
"Stages of Growth" AND "Model" AND "Health"
"Stages of Growth" AND "Model" AND "Hospital"

Finally, there are other models for different areas: maturity model for the PACS area developed by Wetering and Batenburg [49], the Healthcare Usability Maturity Model [50] in the area of usability in health systems, Healthcare Analytics Adoption Model [51] in the area of data analysis, Hospital Cooperation Maturity Model [41] in the networking area, Telemedicine Service Maturity Model [52] in telemedicine and IDC's Mobility Maturity Model for Healthcare [53] in the area of mobile platforms and devices.

Quintegra maturity model for electronic healthcare (eHMM)

The Maturity Model for electronic Healthcare is a model that incorporates all service providers associated with the health process. It is adaptable to any provider at any level of maturity [2]. The eHMM Maturity Model provided by Quintegra illustrates the transformation of an e-health process from an immature stage to a nationwide stage. According to its authors, the stages of maturity of this model provide a roadmap for health organizations to adopt continuous improvement of healthcare processes.

Based on the study conducted by Quintegra we have identified several features that illustrate the nature of the progression of maturity. According to this model, the areas that showed progression in maturity are: timeliness of process, data access and accuracy of data, process effort, cost effectiveness, quality of process results and utility or value to stakeholders.

IDC healthcare IT (HIT) maturity model

IDC (Health Industry Insights) developed a maturity model that describes the five developmental stages of hospitals IS. Each step is supported by the capabilities of the previous stage. This maturity model, called Healthcare IT (HIT) Maturity Model, has been used worldwide by IDC to assess the maturity of the hospitals IS (HIS). Also, it has been used to compare the average maturity between regions and countries of different continents [42]. This model has five stages, namely: basic HIS, advanced HIS, clinical HIS, and digital hospital and virtual hospital.

IDC's mobility maturity model for healthcare

More recently, IDC Health Insights proposed a maturity model for health care organizations. It consists of stages, measures, results and actions to advance along the path of maturity in the context of mobility toward a mobile culture. This model resulted as consequence of new opportunities associated with the value of mobility. It is an answer to the need for exploring alternative technologies, reengineering of business processes, availability of qualified personnel and development and

implementation management of platforms and mobile applications [53].

To help healthcare organizations achieving their mobility strategies, IDC Health Insights has developed a maturity model consisting of five stages (ad hoc, opportunistic, repeatable, managed and optimized) and four critical measures (strategic intent, technology, people, and processes). In addition to the model, IDC also has featured a guide with actions for healthcare organizations to move effectively through the stages of maturity model.

HIMSS electronic medical record maturity model (EMRAM)

HIMSS Maturity Model for Electronic Medical Record is a model for the identification of various stages of maturity in the area of Electronic Medical Record (EMR) of hospitals [43]. In these times, understanding the performance of EMR in hospitals is a challenge in the health care context [43]. The HIMSS Analytics (Healthcare Information and Management Systems Society) developed an adoption model to identify the stages of maturity of the EMR from the limited ancillary department systems to paperless EMR environment [54]. The model proposed by HIMSS Analytics is named EMR Adoption Model (EMRAM) and consists of 8 stages. According to HIMSS Analytics, the structure of this model ensures that a stage is reached only when all their applications are operational.

HIMSS continuity of care maturity model (CCMM)

It was created to help the optimization of results in health systems and patient satisfaction. The HIMSS Continuity of Care Maturity Model (CCMM) goes beyond Stage 7 of EMRAM [44]. It consists of 7 stages and it is based on the EMRAM structure. This global maturity model addresses the convergence of interoperability, exchange of information, coordination of care, patient involvement. Its goal is the efficient management of health for the whole of the population and also at the individual level [44]. This model also has the ability to assess the implementation and use of IT by the health service providers in order to optimize clinical and financial outcomes.

With regard to the benefits of using this model, we can highlight the guidelines for the design of a solid strategy, at national and regional levels. Appropriate measures are taken in a timely manner and include all stakeholders [44]. As an example of these guidelines, we highlight the standardization of: IT systems, privacy, patient involvement, etc.

Electronic patient record maturity model (EPRMM)

According to the NHS (United Kingdom National Health Service), there are six different stages of functionality implemented cumulatively until a complete and exhaustive

Electronic Patient Record (EPR) [45] is achieved. The adoption of an ERP system has been seen as a goal of health care organizations. In fact, it is intended to improve the efficiency of the organizations in the treatment of patient information, timely provision and needs at the point of care. As it progresses, more information will be available in the information system, whether using traditional computers, mobile phones or portable devices. The EPR system functions as the main source of all patient information. It keeps the complete medical record and will be available online at the point of contact with the patient.

Patient records/content management maturity model (forrester model)

Forrester Research Inc. has developed a model with three stages for the area of EMR. This model was developed in order to help health care providers to assess their systems, the way they collaborate and interact, the state of the workflow, and most important, determining the map to get to the next phase. According to Clair [46], this three stages model includes four dimensions or influencing factors: access, interoperability, content features and planning and strategy. In addition to the model itself, Forrester Research Inc. has also developed a manual to drive systems to the next stage. The three stages of this model are: Paper- or imaged-based patient records dominate, Access to standalone repositories improves and Access to the complete digital medical record is role-based.

NEHTA interoperability maturity model (IMM)

The provision of health care involves many different stakeholders, including both the technical and organizational informational area. The ability of these actors to interoperate will have a strong impact on the delivery of health care safely and confidence along the stages [47]. The constant evolution of technology and the changes in clinical practice bring us to assess the ability to take advantage of these developments. The National E-health Transition Authority of Australia (NEHTA) produced an Interoperability Maturity Model (IMM) which is based on three components: five stages CMMI (Capability Maturity Model Integration), a set of interoperability goals, and an evaluation model focused at the national level.

The five stages of this model are constrained by organizational, informational and technical dimensions at local, corporate and national level. Interoperability targets for reuse, evolution, standards, scope, scalability, configurability and explanation are shared between the three dimensions. The objectives associated with business and governance are set to the organizational dimension. Informational dimension targets are classified as: data format and semantics, meta-data, ownership

and rights, common building blocks. Targets associated with the technical dimension are classified as: interface specification, functional decomposition, communication protocol. n-tier architecture and technical policy separation.

NHS infrastructure maturity model (NIMM™)

The NHS Infrastructure Maturity Model (NIMM) aims to provide a coherent framework for healthcare organizations. The organization will be able to measure its own current technological infrastructure capabilities in specific areas and consequently, to identify and prioritize activities that enhance these capabilities [48]. Therefore, the NIMM is a model of evaluation of maturity technological infrastructure.

This model adopts the Key Capabilities Self-Assessment Tool to support IT organizations associated with NHS. It is used for preparing a self-assessment of technology infrastructure assessing the maturity of their capabilities. Furthermore, it helps in the identification of improvement maturity projects.

The NIMM has a holistic approach: it takes in account technological and IT infrastructure organizational sides. In fact, it has 72 evaluation capabilities grouped in 13 categories. The categories are divided into technological aspects and organizational issues. The technological aspects are: Common Applications & Services; Operating Systems; Infrastructure Hardware Platforms; Network Devices & Services; IT Security & Information Governance; Infrastructure Patterns & Practices; End User Devices. The organizational issues are: Infrastructure Governance; Business Alignment; Procurement; People & Skills; Financial Management; Principles, Standards, Procedures & Guidelines.

Healthcare analytics adoption model (HAAM)

Health care has moved through three phases of computerization and data management, i.e., data collection, data sharing and more recently data analysis. The data collection phase is characterized by the implementation of EMRs. It does not have a significant impact on the quality or the cost of health care [51]. According to these authors, it will be necessary to invest in practices associated with data analysis and use of data warehouses. In this sense, the HAAM model was developed to accelerate the progress of maturity analytical data in health care organizations.

Healthcare Analytics Adoption Model (HAAM) is a model to measure the adoption and use of data warehouses and data analysis in health care [51]. This model was initially developed by Sanders in 2012 [55] as result of years of work in this area. He anticipated foreseeable needs of the healthcare industry. This model is based on EMRAM model [43]. It received numerous contributions from several healthcare consultants resulting in an update version in 2013. This model has a similar approach as EMRAM to assess the adoption of data

analysis in health. It is structured in 8 stages. Each one of them performs through several capabilities that define the path of health organizations to data analysis maturity. In addition, each stage includes a progressive expansion of analytical capabilities in the following four areas: new data sources, complexity, data literacy and data timeliness.

Hospital cooperation maturity model (HCMM)

This model aims to conceptualize an evolutionary path for improving cooperation within hospital and between hospitals [41]. The authors felt the need to develop the model because of the real and observable changes hospitals are suffering. It was intended to cope with increased competition and market dynamics. The model application would force specialization and cooperation.

The Hospital Cooperation Maturity Model helps hospitals in the evolution of strategic, organizational and technical capabilities in a systematic way. The model contributes to structures and collaborative processes become efficient and effective. HCMM consults a total of 36 reference points, reflecting three distinct organizational dimensions relevant to the ability to cooperate. On the one hand, the model can be used as the basis for comparative evaluation of the quality of cooperation between a specific hospital and their business partners; on the other hand, it may be applied as a common basis for sharing learning and improvement actions.

As mentioned above, the HCMM is structured in three layers or dimensions. The first one is a strategic layer set to measure the ability of a hospital to cooperate with external partners. The second one is the organizational layer set to measure the ability to cooperate within the hospital (i.e., between different departments, divisions, etc.). Finally, the third layer is an information layer used to measure the technical capabilities of a hospital to provide the IT infrastructure needed for internal and external cooperation efficiently and effectively.

PACS maturity model (PMM)

The PACS maturity model (PMM) describes the process maturity of hospitals based on PACS. The analysis is developed in terms of functionality and integration of the work flow practice. PMM is a descriptive and normative model. It was developed as a guide for evaluation and strategic planning [49]. In this regard, the PMM can be used for strategic planning. The model incorporates growth paths to reach higher stages of PACS maturity. However, this model omits a relevant issue. The development used in this maturity model will be different in different areas of the same organization. Besides, the maturity maximization cannot be effective or "ideal" in all circumstances [56].

On the basis of 34 scientific papers literature review on PACS and subsequent meta-analysis, Wetering and Batenburg [49] identified three major trends in the evolution and maturity of PACS: (1) Radiological and hospital-wide process improvements, (2) Integration optimization and innovation, and (3) Enterprise PACS and EPR. From there, the authors defined five dimensions (strategy and policy, organization and processes, monitoring and control; information technology, and people and culture) and five PACS maturity stages that hospital can achieve: infrastructure, process, clinical process capability, integrated managed innovation and optimized enterprise chain.

Telemedicine service maturity model (TMSMM)

The authors [52] consider that this maturity model can be implemented to measure and manage the health system capability to provide clinical health care at a distance. Indeed, this model can be used to measure, manage and optimize all components of a telemedicine system and the health system in which it is applied. The term "telemedicine" was first used in 1970 and refers to the provision health services (medicine) at a distance (tele).

The TMSMM model is based on three dimensions. The intersection of each pair forms a matrix, each one with specific meaning and function. First, five domains are defined to provide a holistic view of all the factors that impact the implementation of telemedicine services. Secondly, the telemedicine service dimension is built by five micro-level processes, a meso-level process and one macro-level process per domain. The third domain is the maturity scale, which provides assessment standards for maturity measurement. The domain adopted by this model is the 5 M's ("Man - Users Communities", "Machine - Infrastructures ICT", "Material - EHR systems," "Method - Change Management" and "Money - Financial Sustainability"). The maturity scale is based on the stages indicators of CMM maturity model (Capability Maturity Model). There are 5 stages. Stage 1: ad hoc - service is unpredictable, experimental, and poorly controlled; stage 2: managed - the service is characterized by projects and is manageable; stage 3: standard - the service is defined as a standard business process; stage 4: quantitatively managed - the service is quantitatively measured and controlled; stage 5: optimizing - focus on continuous improvement.

Healthcare usability maturity model (UMM)

The Healthcare Usability Maturity Model helps healthcare professional to assess the usability stages of IST of organizations and how they can advance to the next stage [57]. The authors of this Maturity Model led a Usability Taskforce created by HIMSS [50]. Its objective was to develop a new model

Table 2　Summary and comparison of maturity models for IST healthcare

Designation	Health Field	Stages	Research method	Influencing factors / dimensions	Assessment tool	Reference model	Author/Year
Quintegra Maturity Model for electronic Healthcare (eHMM)	General	7	n/a	Entities; Department; Infrastructure	n/a	n/a	Sharma [2]
IDC Healthcare IT (HIT) Maturity Model	General	5	n/a	Types of IS	n/a	n/a	[42]
IDC's mobility maturity model for healthcare	mHealth	5	Survey, Case study	Intent; Technology; People; Processes	IDC's Mobility Maturity Model Guidance	CMM	[53]
HIMSS Maturity Model for Electronic Medical Record (EMRAM)	EMR	8	n/a	Types of IS	EMR Penetration Assessment Tool	n/a	[54]
HIMSS Continuity of Care Maturity Model (CCMM)	General	8	n/a	Types of IS	n/a	EMRAM	[44]
Patient records/content management maturity model (Forrester Model)	EMR	3	Interviews with US healthcare providers	Access; Interoperability; Content Features; Planning & Strategy	Guidance To Get To The Next Phase	n/a	[46]
Maturity Model for Electronic Patient Record (EPRMM)	EMR	6	n/a	EPR System	n/a	n/a	[45]
NEHTA Interoperability Maturity Model (IMM)	Interoperability	5	ODP standards (open distributed processing)	Organisation; Information; Technical	Yes	IMM / CMMI	[47]
NHS Infrastructure Maturity Model (NIMM)	Infrastructure IT	5	n/a	Process; People & Organisation; Technology; Security & Information Governance; Strategy Alignment & Business Value	Key Capabilities Self-Assessment Tool	CMM	[48]
Healthcare Analytics Adoption Model (HAAM)	Data Warehouse & Analysis	9	Data gathered by observation and learned in a structured educational curriculum, experts opinions	New Data Sources; Complexity; Data Literacy; Data Timeliness	Healthcare Analytics Adoption Model Self Inspection Guide	EMRAM	[51]
Hospital Cooperation Maturity Model (HCMM)	Networking/ Cooperation	4	Interviews, Focus Group, prototype	Strategic; organizational; Information	HCMM Instantiation	CMM	[41]
PACS Maturity Model (PMM)	PACS	5	Literature review, qualitative meta-analysis approach	Strategy & Policy; Organization & Processes; Monitoring & Control; IT; People & Culture	Yes	CMMI	[49]
Telemedicine Service Maturity Model (TMSMM)	Telemedicine	5	Literature review, workshop with health and IT professionals, case study	Man; Machine; Material; Method; Money	Yes	CMM	[52]
Healthcare Usability Maturity Model (UMM)	Usability	5	Literature review, case study	Focus on users; Management; Process & Infrastructure; Resources; Education	Yes	Schaffer UM, Nielsen UM, Earthy UM	[50]

for identifying elements and main steps involved in successful integration of usability in a healthcare organization.

The development of this model was based on the evaluation of the characteristics of three usability maturity models [58–60] and how they could be adopted in healthcare. In this model, each phase enables organizations to identify their current stage of usability and also includes guidelines to advance to the next stage. The five stages are: unrecognized, preliminary, implemented, integrated and strategic. Within each stage, these elements are taken in account: focus on users, management, process and infrastructure, resources and education.

Summary and closing remarks

The 14 Maturity Models of IST in health care resulting from this literature review are summarized in Table 2. Besides the identification of each model and its authors, is presented the health field (general or specific), number of stages, research method adopted in its development, influence factors considered, assessment tool and model that was used as reference for its development.

As a result of this literature review, it was found that the maturity models for health care IST are developed by different types of entities, including national and international health care companies, research organizations in ICT as well as academic experts in this domain.

It was also found that there are two approaches: in one hand, the highly specialized models that have resulted in a health subsystem and in the other hand, the more comprehensive models, i.e. models representing the hospital IS as a whole (e.g. eHMM, IDC HIT, CCMM). Also, it was found that most of the analyzed maturity models does not disclose the design process nor the research options for development and validation [41], thus compromising the researcher work.

It appears that CMM and CMMI his successor, is the reference model for the design of Maturity Models in the health sector. This model has served as inspiration for dozens of maturity models in the various areas of IST [61]. In fact, 6 of 14 identified models base its structure on the CMM model.

Regarding the number of maturity stages, there are models from 3 stages as the Forrester Model [46] up to 9 stages of HAAM [51].

It is noted that not all the identified maturity models with various dimensions or influencing factors have explicitly broken down the characteristics for each stage of maturity. In fact, from 11 maturity models with influence factors, only 5 discriminate characteristics for each stage [2, 41, 46, 50, 52]. With regard to influence factors, it was detected entries with the same name in different maturity models and entries with different names but with the same meaning or interpretation (result of using different terminology adopted by the authors).

Also, the authors did not apply weights to each of the influencing factors, that is, in the assessing process of the overall maturity of health IST, all influencing factors have the same importance.

In the case of adoption of a tool for assessing the system maturity, it was found that most of the models, besides focusing on the assessment of the system's maturity, they pay attention to an improvement path of such maturity. However, not all have a properly systematized process to move to a higher maturity level.

Some maturity models are developed by health national and supranational organizations, mainly corporations, who are dedicated to technological developments, such as IDC Health Insights and HIMSS or even by national health organizations as the NHS or NEHTA. This fact complicates the process of search and analysis of their respective models, since access to information is restricted. Consequently, it is not possible to know the development methodology and validation adopted. Moreover, only a small part of the models were published in IS Journals ([41, 45, 49], while the rest are published mostly in white papers, making it impossible thus attest to its validity in the context of peer review.

As a result of this study, none of the identified models has a sufficiently broad scope covering all areas and subsystems of health care organizations. In this sense, a maturity model with a holistic approach including a comprehensive set of influencing factors is missing. In this perspective, a new model to fill the gap should be designed. This new model, should include the main influence factors with different weights depending on their relative importance and its development should be supported by rigorous scientific methods of conceptualization and validation.

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