Journal of Business Research 94 (2019) 388–399

Contents lists available at ScienceDirect

Journal of Business Research

journal homepage: www.elsevier.com/locate/jbusres

A Maturity model for hospital information systems

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ARTICLE INFO

Keywords:
Stages of growth
Maturity models
Hospital information system
Management
Health

ABSTRACT

In the last five decades, maturity models have been introduced as guides and reference frameworks for information system (IS) management in organizations within different industries and sectors. In the healthcare domain, maturity models have also been used to address a wide variety of challenges, complexities and the high demand for hospital IS (HIS) implementations. The present paper describes a research project focused on the development of a comprehensive maturity model applied in the HIS context. The outcome of this research is the HIS maturity model (hereafter referred to as HISMM), which includes six stages of HIS growth and maturity progression. The HISMM has the peculiarity of congregating a set of key maturity-influencing factors and respective characteristics, enabling not only the assessment of the global maturity of a HIS, but also the individual maturity of its different dimensions.

1. Introduction

The rapid development of the information and knowledge society, and consequently the rapid advancement of information and communication technologies (ICTs), has revolutionized the way in which we interact with each other (Martin, 2017). The convergence between the acceleration capabilities of computers, the range and expansion of the Internet and the increase in the ability to capture and leverage the knowledge in a digital format are key drivers for the technological revolution that we live in today. The current information society has the true potential to revolutionize healthcare (Wager, Lee, & Glaser, 2017), as it could change the relationship between the patient and the professional, providing valuable opportunities for health professionals to deliver healthcare services effectively through the use of information systems and technologies (ISTs) to their patients, while providing them easy access to relevant (clinical) information. The possible side effects of this major information society development, as well as major demographic shifts, the lack of qualified health professionals and the high expectations and demands among patients, local administrators or health insurers, could hinder the fulfilment of this mission (Fitterer & Rohner, 2010). Healthcare systems around the world are, at present, facing considerable pressure to reduce costs, enhance and improve service efficiency, and expand access, while maintaining or even improving the quality of health services provided (Ahtonen, 2012; Jha et al., 2009; Ludwick & Doucette, 2009). This is also, in part, due to the fact that healthcare is a critical social and economic component of modern societies, with the adoption and effective use of health ISTs being crucial to its success (Buntin, Burke, Hoaglin, & Blumenthal, 2011; Haux, 2010; Hendrikx, Pippel, Van de Wetering, & Batenburg, 2013; Ludwick & Doucette, 2009). As such, there are strong expectations that a wider adoption of ISTs in the health field will contribute to the process of improving the health of individuals and the performance of providers, yielding improved quality, cost savings and greater engagement by patients in their own healthcare (Blumenthal, 2010). However, there is evidence that the implementation of ISTs, without any adaptation of the relevant structures, as well as the strategic and organizational processes behind it, will not necessarily generate the expected benefits (Mettler, 2011). Several studies emphasize the importance of facing this challenge by finding appropriate models for use in the facilitation, evaluation and measurement of the success rate of projects in the field of health systems (Van Dyk & Schutte, 2013). Maturity models fall perfectly within this framework.

2. Maturity models

The concept of maturity models is increasingly applied in the IS field, both as an approach needed for continuous improvement (Paulk, Curtis, Chrissis, & Weber, 1993) and for its evaluation (Fraser, Moultrie, & Gregory, 2002). Since its initial conception in the early 1970s (Gibson & Nolan, 1974; Nolan, 1973), a number of different instances has been developed in science and practice. However, as organizations face constant pressures to achieve and maintain competitive advantage by

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https://doi.org/10.1016/j.jbusres.2017.12.012
Received 15 August 2017; Received in revised form 6 December 2017; Accepted 8 December 2017
Available online 21 December 2017

inventing and reinventing new products and services, while reducing costs and time to market, as well as improving quality at the same time, there is a continuing need to develop new maturity models, since they help decision makers to achieve these goals (Mettler, 2009). On the other hand, through the incorporation of formalism into the improvement of activities, decision makers within organizations can determine whether the potential benefits are being achieved or not. In addition, "*Conflicts of interest can be avoided by using a measurement model developed externally to the organization*" (p. 97) (Fraser & Vaishnavi, 1997).

During the last five decades, several maturity models have been proposed, which differ not only in terms of the number of stages, maturity-influencing factors and intervention fields (Rocha, 2011), but also with respect to their quality and applicability (Pöppelbuß & Röglinger, 2011). These constituent factors each identify the characteristics that typify the focus of every maturity stage; that is to say, these factors act as descriptors or variables of reference for the characterization of each stage, while providing the necessary criteria to reach a specific maturity level (Becker, Knackstedt, & Pöppelbuß, 2009). In other words, maturity models facilitate orientation through an evolutionary process, incorporating the procedures for improving activities (Mettler & Rohner, 2009b). Although, there currently is no holistic understanding of the relevant principles of form and function maturity models as design products should meet (Pöppelbuß & Röglinger, 2011).

Maturity models are available to respond to many different challenges. These models provide information for organizations to address the problems and challenges in a structured way, providing both a reference point to assess the capabilities and a road map for improvement (Caralli & Knight, 2012). In general, the 'typical' IS maturity model is commonly applied within organizations in order to assess the as-is and to-be situation, which in turn relates to the associated improvement activities (Iversen, Nielsen, & Norbjerg, 1999).

3. Problem and objectives of research

Healthcare institutions, and hospitals in particular, in conjunction with government organizations, are starting to realize that the reasons behind a certain inability to properly manage health processes are directly related to the limitations of technological infrastructures and the lack of efficiency in their management (Freixo & Rocha, 2014; Sharma, 2008). An analysis of the health context clearly shows the size and importance of the technological transition problem (Sharma, 2008). In addition, IT operations have grown in complexity to meet the requirements of this area of activity. This increase in complexity, in turn, has led to the introduction of many new systems, procedures, processes and approaches to business integration, as well as the emergence of new companies offering innovative services in this field. As a consequence, many products and services are too immature to be consumed by a HIS, which is in a state of change and requires, as always, a level of performance and effectiveness that meets their needs. Based on this scenario, it is difficult to assess whether the management of such changes and progress in monitoring them on an ongoing basis is carried out effectively. Moreover, it is not easy to manage systems, their interactions and interrelated processes that are in constant motion, as it is not easy to manage the impact of low interoperability, security, reliability, efficiency and effectiveness.

It should be noted that the benefits of modern technology in the health field, supported by better methods and better tools, cannot be obtained through undisciplined and chaotic processes (Gonçalves & Rocha, 2012; Gonçalves, Silveira, & Rocha, 2011). For this reason, we believe that IS management in health organizations can benefit from the use and adoption of IST maturity models.

Various maturity models have been proposed over time, both for the development of individuals and for the general evolution of organizations or the particular evolution of the IS management function. These models mainly differ in terms of a number of stages, variables of evolution and focus areas (Mettler & Rohner, 2009a; Rocha, 2011). Each of these models identifies certain characteristics that specifically target the objectives of the next stage of growth. These types of model can be applied situationally within healthcare in order to strategically plan for IST maturation, based on the degree of alignment between the hospital strategy and the selected growth path, as well as associated investments and improvement activities (van de Wetering et al., 2011; van de Wetering, Batenburg, & Lederman, 2010).

Within the healthcare domain and other organizations in the health field, several maturity models have been proposed, although these models are still at an early stage of development (Mettler & Rohner, 2009a; Rocha, 2011). Studies show that maturity models in the health field are not comprehensive, lack detail, do not provide tools for determining maturity and are without any characteristics relating to maturity stages, as structured by maturity-influencing factors.

Moreover, the very concept of maturity models is not exempt from criticism. For example, Pfeffer and Sutton (1999) argue that the purpose of these models is to identify a gap that can be closed by subsequent actions for improvement. However, many of these models do not describe how to effectively perform these actions, as demonstrating how to close the gaps can be very difficult to do. The most important point of criticism about maturity models, however, concerns their poor theoretical basis (Becker et al., 2009; Biberoglu & Haddad, 2002; Mettler & Blondiau, 2012). Most models are based on "best practices" or "success factors" associated with the projects of organizations that have demonstrated positive results. Thus, although these practices are compatible with maturity models, there is no guarantee that an organization can succeed. There is no consensus on the "true path" to ensure a positive outcome (Montoya-Weiss & Calantone, 1994). According to de Bruin, Freeze, Kulkarni, and Rosemann (2005), the reasons for these sometimes ambiguous results from maturity models stem from insufficient investment in testing models in terms of validity, reliability and generalization, as well as in the limited documentation about how to develop and design a model of this type.

On consulting the extant and current literature, it was found that, as far as it was possible to establish, there is no model in the health field that is sufficiently comprehensive and detailed to assess the HIS maturity in its various aspects. In fact, a performed content analysis on scientific articles, guides, white papers, reports and websites, all of which contained information on maturity models in the health field, also revealed the lack of maturity models with maturity dimensions or maturity-influencing factors, taking into account the weighting of their importance.

3.1. Research questions

Given these constraints, it was appropriate to develop a research project that would contribute to an increase in the knowledge of healthcare maturity models, in order to facilitate an improvement in the practice of assessing and promoting the maturity of IS in this setting. Based on the problem description, the following research question was formulated:

> "*Is there a comprehensive model, which consists of several maturity-influencing factors and maturity stages, that can also be applied to HIS management?*"

From this research question, the following "sub-questions" were proposed:

RQ1 - Which influencing factors are associated with the maturity stages that are considered to be the most important by IS managers in the health field?

RQ2 - Can the maturity for each maturity-influencing factor be assessed in the context of the maturity stages of a HIS?

RQ3 - Can a HIS take on different maturity stages, taking into account the different maturity-influencing factors?

RQ4 - Can a comprehensive maturity model be used in the

evaluation of the HIS maturity level, taking into account the weighting of the importance of the different maturity-influencing factors?

3.2. Research objectives

This research comprised various objectives. First, it was intended to review and discuss the main concepts related to maturity models, as well as identify and summarize the main maturity models adopted in IS management and the characteristics of the various stages involved. The review also sought to identify the key maturity-influencing factors within the IST field that could be incorporated into a new comprehensive maturity model, which could serve as a tool for HIS management. Finally, it was intended to submit a proposal for a maturity model, which included the main maturity-influencing factors with different weights, depending on their relative importance.

4. Research methodology

During the initial phase of this project, a reflection was made on three aspects, which were considered cornerstones for this particular research, that is: (1) the goals of the research; (2) the research methodologies; and (3) the existing conditions for the realization of this project (i.e., organizations and contacts available to collaborate on a project of this nature). Based on this reflection and taking into account the research question and the objectives established, we decided to choose an approach with the inclusion of the following methods: a systematic literature review and design science research (DSR).

In this study, the aim of the literature review was to identify and discuss a set of concepts and key aspects related to IS maturity models in general, as well as gather, analyze and systematize a set of contributions regarding IS maturity models in the health field in particular. In addition, different ways to develop a conceptual maturity model in the IS field were also analyzed and summarized. At the end of the systematic literature review, one of the most important results, in addition to a description of the state of the art concerning IS maturity models in the health field, was the identification of an initial set of maturity-influencing factors associated with different maturity stages.

In relation to the other adopted method, this work used DSR methodology in line with the guidelines from Hevner, March, Park, and Ram (2004) and methodology for the development of maturity models, as proposed by Mettler (2010), which is consistent with the said guidelines. Under the DSR method, the maturity-influencing factors of different maturity models in the health field, as identified in the literature review, were characterized. Subsequently, these factors were prioritized, based on a questionnaire that was sent to a community of health professionals (mainly HIS managers). Following identification of the main maturity-influencing factors, their characterization at different stages of the model was determined, giving rise to the first version of the new model. The validity of this model was tested via contributions by a restricted set of specialists in the health field and those with whom interviews were conducted. It should be noted that the construction of the new model as a result of a DSR process is framed in one of the three types of artifacts, as defined by March and Smith (1995).

4.1. Research activities

The project observed a mixed methods research approach, specifically an explanatory sequential mixed method, starting with a quantitative method and followed by a qualitative method (Creswell, 2014) for explanation and insights. In order to develop the new HISMM, we agreed upon a set of activities in compliance with established research methodologies and the most suitable for this type of project (see Fig. 1).

4.2. Literature review

In order to conduct a comprehensive and structured literature review, it was necessary to define a strategy by which to systematically identify and analyze the available literature on maturity models in the context of healthcare ISTs. An initial review of the literature provided criteria for selecting the approach and establishing the strategies to be applied to this project.

The first chosen strategy, from Webster and Watson (2002), suggests a structured approach involving three basic steps: to identify the relevant literature in the main sources (i.e., “leading journals”) and recognized conferences; to conduct a search in the reference section of studies identified in the first step, in order to identify potential works of relevance; finally, to perform a search, via the Web of Science, of works that cite those identified in the previous two steps.

The second strategy, proposed by Tranfield, Denyer, and Smart (2003), suggests five steps for a systematic review of the literature. The first stage defines terms, keywords and combinations as criteria to be applied in the literature review. The next phase is to identify relevant works that contain the keywords and terms defined above. In the third phase, an assessment of identified papers should be carried out, followed by the selection of works that meet certain quality criteria. In the fourth phase, relevant information from the selected literature should be extracted. Finally, in the fifth phase, a synthesis of data is conducted.

An analysis of the strategies described above showed that the approach proposed by Webster and Watson (2002), although simple and easy to implement, is not completely suited to this work. The literature on maturity models of healthcare information systems is limited to major journals and conferences. With regard to Tranfield et al.'s (2003) approach, no clear procedure was found 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. Despite the concerns mentioned above, a literature review was carried out based on this approach with minor modifications and simplifications (Fig. 2). It should be noted that the second phase of Tranfield et al.'s (2003) approach was replaced by the three basic steps described by Webster and Watson (2002).

The terms and keywords were employed as literature searching criteria, taking into account that most of the relevant literature on maturity models of healthcare information systems is written in English. “Maturity Model” and “Stages of Growth”, combined with other terms relevant to this knowledge area (Hospital, Health, eHealth), were used for the search iterations.

The search criteria were applied to the literature review. Given that Tranfield et al. (2003) failed to suggest any procedure for this stage, the approach proposed by Webster and Watson (2002) was followed, with two changes made: in the first step, the main sources were replaced by the major web platforms of scientific literature; and, in the third step, the Web of Science platform was replaced by the search engines Google and Google Scholar.

Next, we searched for scholarship 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 carry out a data analysis to identify related references, as suggested by Webster and Watson (2002). Finally, given that the disclosure of much of the information on maturity models of healthcare information systems has been accomplished through technical reports, research and white paper projects, we utilized a more extended search using the Google and Google Scholar search engines, thereby ensuring the identification of other work of relevance to this particular study. It should be noted that our study found that, overall, research on maturity models is increasing; however, much of the published material related to healthcare is not present in leading IST journals.

After identifying a wide range of work in this area, according to the approach proposed by Tranfield et al. (2003), it was necessary to define quality criteria for the selection of suitable studies for this research.

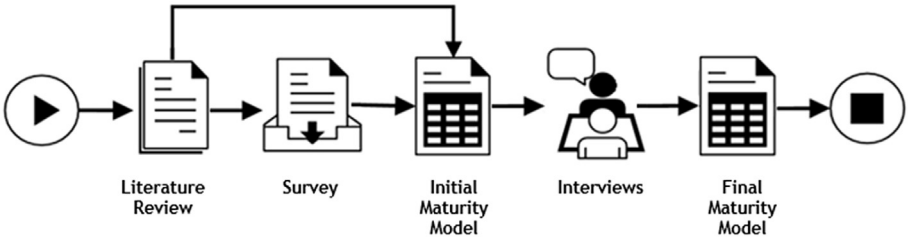

Fig. 1. Activities carried out in the development of the HISMM.

However, despite the difficulty in defining quality criteria for qualitative work, it was found that few of the available models presented details of their design process and decisions taken in development (Mettler & Blondiau, 2012). Hence, we understood that it was convenient to apply a simple and comprehensive quality criterion; in other words, we decided to gather together studies when it was possible to clearly identify the context (motivation, goal, results and benefit) in which maturity models were mentioned.

In the end, after processing all the cases, 14 models were selected by taking into account the following: description, scope, number of stages, influencing factors, development methods and validation process.

4.3. Survey

The rationale behind the administration of a survey was to answer two research questions posed by this research. The aim of these research questions was to identify the most important influencing factors to be adopted in a healthcare IST maturity model (RQ1) and confirm whether the maturity of these influencing factors can be evaluated (RQ2). Answers to these questions were obtained via the analysis of insights and opinions, as provided by a group of experts on healthcare ISTs, concerning 12 maturity-influencing factors (healthcare IST subareas) identified by our systematic literature review (Carvalho, Rocha, & Abreu, 2016a, 2016b).

In order to guarantee the validity and consistency of the results, we tried to identify and invite a group of experts in the field being studied, whose knowledge could ensure the credibility of the obtained answers. Diversity within the expert panel was also a concern, as we wanted to ensure the level of heterogeneity that was necessary for the success of the study. Regarding the sampling procedures, we opted for non-probability and convenience sampling, due the difficulty to obtain a random or stratified sample of the population of interest (healthcare IST experts).

Thus, through a selection process involving a broad range of personalities, we initially invited 188 Portuguese healthcare IST experts,[1] of whom only 144 successfully received the invitation to participate; that is, 44 of the 188 emails sent in this survey were returned as failed to be delivered. Of the 144 experts who received the invitation to participate in the survey, 58 agreed to participate (40.3%). However, of these 58 experts, only 46 effectively participated by fully completing the survey. Therefore, the effective participation rate was 79%. Since this domain is characterized by a small number of experts, and considering the participation rates obtained in similar studies, our participation rate can be considered to be quite reasonable. Moreover, for samples with more than 30 elements in each group being studied, the violation of normality and homoscedasticity assumptions does not call into question the conclusions (Gravetter & Wallnau, 2000; Stevens, 1996).

The characterization of the participants was considered important in order to place the results in context and discuss them. With this in mind, we included a set of questions related to profile characterization, which the respondents had to complete on the first page of the online questionnaire.[2] In the process, each expert had to provide the following information: professional category and years of experience in terms of jobs or positions relating to healthcare ISTs.

Where professional experience was concerned, all experts were asked to indicate whether their professional experience in the field of healthcare ISTs involved management, consultancy, teaching or other. In global terms, among the group of experts who participated in our study, 29 (63%) stated that their professional experience involved management or consultancy in the IST field, eight (17%) referred to teaching or research, five experts (11%) referred to experience in unit/department management and four (9%) indicated other areas. Table 1 shows the distribution of participants according to their professional category.

Another aspect considered important in the characterization of the participants was their experience in jobs involving healthcare ISTs. Thus, the experts were asked to indicate whether the duration of their experience corresponded to less than three years, three to six years, or more than six years. In the group of 46 experts who actively participated in the study, the vast majority were largely experienced in this field. Indeed, 39 experts (85%) indicated that they had more than six years of experience in healthcare ISTs; meanwhile, only one (2%) indicated that they had less than three year experience and six (13%)

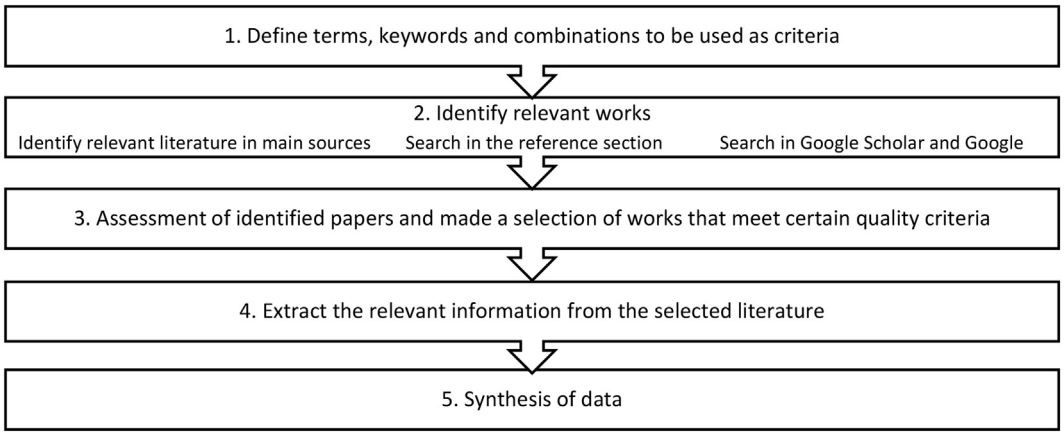

Fig. 2. Methodology adopted for the systematic literature review.

Table 1
Characterization of the respondents in terms of professional category.

Professional category	No.	Percentage
IS manager	22	47.82%
IST consultant	7	15.22%
Unit/department manager	5	10.87%
Professor/researcher	8	17.39%
Other	4	8.70%

Table 2
Characterization of the respondents in terms of years of experience in the health field.

Experience in the health field	No.	Percentage
Less than 3 years	1	2.17%
3 to 6 years	6	13.04%
More than 6 years	39	84.78%

indicated that they had three to six year experience. Table 2 shows the distribution of experts by years of experience in the healthcare IST field.

Bearing in mind the results of this respondent profile analysis, and the high percentage of consultants and managers, both in units/departments and in IS roles (74%), as well as their significant experience in the health field, as confirmed by 85% of respondents having more than six years of experience, it is noteworthy that the group of respondents who participated in our survey represented a significant part of the knowledge available in this field.

The administration of the survey began on 18th January 2016, with the questionnaire made available for a period of 10 days. The 144 healthcare IST experts were notified by email of the survey dates. Besides the notification and a description of the study, an online link to access the questionnaire was made available. As previously mentioned, 46 experts successfully completed the questionnaire within the stated period.

Based on the results of this survey, we conclude that there are six influencing factors (Table 3) that can be considered to be the most important in healthcare ISTs (Carvalho et al., 2016a; Carvalho, Rocha, & Abreu, 2017); in this sense, they will inevitably be applied to the new maturity model proposal. With regard to the other less important influencing factors, their inclusion in the new maturity model proposal will be subject to consideration. Bearing in mind the encompassing character of the new maturity model, the definitive exclusion of these six influencing factors was ruled out. Notwithstanding, when considering their inclusion, we verified whether any of the factors was, to any extent, related to any of the six most important influencing factors. Based on this presupposition, the influencing factors of “Interoperability”, “Cooperation” and “mHealth” were considered to be appropriate for incorporation into “Systems and IT Infrastructure” without compromising this factor's identity. Similarly, the characteristics of “Usability” could be incorporated into “People”, while the characteristics of “PACS” and “Telemedicine” could be incorporated into “Electronic Medical Record”.

After identifying the most important healthcare IST influencing factors (that is, the six influencing factors to be included in our new maturity model proposal), we needed to assign different weights to these factors. Indeed, a global HIS maturity evaluation must be based on the maturity of its different influencing factors, without disregarding the importance of any of them. In Table 3, we present the weights of the six influencing factors, based on the relative importance of each subarea. This estimation is the mean of the two rankings obtained from the surveys carried out by experts.

Table 3
Relative weights of maturity-influencing factors to be included in our new maturity model proposal.

Influencing factors	Score	Maturity weight
People	236	19.1%
Electronic medical record	208	16.8%
Systems and IT infrastructure	207	16.7%
Strategy	206	16.7%
Information security	194	15.7%
Data analysis	186	15.0%

4.4. Interviews

Taking into account the objective of our research, which involves the validation of the HISMM, we decided to carry out semi-structured and individual interviews with a number of ITS professionals, who are highly experienced in the management of Portuguese hospitals. Semi-structured interviewing, in our case, was the most appropriate method, as it is neither entirely open-ended nor defined by a precise set of questions (Quivy & Campenhoudt, 2003). According to Quivy and Campenhoudt (2003), with this interviewing method, the researcher is expected to prepare a group of relatively open guiding questions in order to obtain certain information from the respondent. These questions should not follow any particular order; rather, the interviewer should allow the respondent to talk and expresses himself as much as possible, in his own words and following the order that suits him the best. However, the interview can be guided (Annex A) whenever the interviewee steers away from the goals in view.

Identifying and selecting HIS experts were considered fundamental steps for this type of study, as the characteristics of the respondents could significantly condition the quality of the information obtained and the confidence in the results achieved. Notwithstanding their undeniable importance, few studies clearly indicate the requirements and procedures to be followed when defining such experts. Due to limitations regarding the number of respondents, we were particularly careful with our selection. Thus, we agreed that the respondents would be highly experienced in HIS management. Additionally, the selection should ensure the representation of different types of hospitals in both the private and public sectors. Finally, this representation should cover different SNS[3] services and institutions, according to the nature of their responsibilities, their expertise and their position within the hospital network (Ordinance 82/2014 April 10). Based on these presuppositions, Table 4 summarizes the information obtained from the five selected respondents who agreed to participate in the present study. Special mention should be made of the experts who received the CIOnet Portugal Award for CIO[4] of the Year in the previous two years.

The interviews were analyzed based on content, which is a method widely used in qualitative research; in other words, this technique analyzes what is explicit in the text in order to obtain the indicators that allow for inferences. For the type of interview selected in this study, we adopted a qualitative analysis approach in order to try and analyze the presence or the absence of one or several characteristics in the text.

As a result of this analysis, we validated the research questions RQ3 and RQ4, while the suggestions for changing the characteristics of different influencing factors in each of the six model stages were incorporated into the HISMM. We observed that, from the 226 model characteristics, nine (4.0%) were moved to a different stage or influencing factor, 15 (6.7%) were reinserted, 10 (4.4%) were renamed and 192 (84.9%) remained unaltered. This high rate of characteristics,

[1] The list of Portuguese experts in healthcare ISTs included IS managers, IST consultants, unit/department managers, professors and researchers. The list was provided by a member of a Portuguese IS health managers group.
[2] Prepared with the LimeSurvey freeware.
[3] Serviço Nacional de Saúde (i.e., the Portuguese National Health Service).
[4] Chief Information Officer.

Table 4
Generic information on interviewees.

Code	Hospital				Experience	Background	Comments
	Type	Population	Beds	HIS staff			
CIO-P	Private	247,000	300	8	5 years	Management IS	CIO of the year 2015
CIO-GI	Group I	119,000	126	3	18 years	Management IS	
CIO-GII1	Group II	277,000	632	6	18 years	Engineering	
CIO-GII2	Group II	334,000	578	16	12 years	Engineering	
CIO-GIII	Group III	562,000	700	18	18 years	Engineering	CIO of the year 2014

which has not received any criticism, shows that the initial model generally accepted by our interviewed managers.

5. Hospital Information System Maturity Model

The HISMM comprises a conventional maturity model structure, that is, a matrix composed of different maturity stages and six maturity-influencing factors, identified as the most relevant for a healthcare IS (Carvalho et al., 2016a). As seen in Table 5, in which our HISMM is briefly described, each factor identifies the features that typify the focus of each maturity stage. These factors emerge as reference descriptors or variables that characterize each stage and determine the necessary criteria to reach a specific maturity stage.

In other words, the HISMM architecture comprehends stages on an evolutionary scale with measurable transitions between them. Each stage is defined by a set of attributes and, when a HIS reveals such attributes, the corresponding stage and the capabilities it embodies have been achieved. With measurable transition states between stages, hospitals can use this scale to (1) define the current maturity stage, (2) determine the next achievable maturity stage and (3) identify the attributes that must be met to reach a new maturity stage.

Next, a brief description of the six maturity-influencing factors included in the HISMM is presented.

5.1. Data analysis

The investigation suggests that companies using *business intelligence* (BI) and *data analytics* (DA), when managing decision-making processes, are more productive and profitable than those who do not (Mathews, 2015). Organizations that intend to increase the use of DA to optimize costs, profitability, productivity and quality should consider strategic investments in this field. Healthcare organizations are clearly no exception to this rule. Within the healthcare field, Hospitals have followed three stages of data computerization and management: namely, data collection, data sharing and (more recently and gradually) data analysis (Sanders, Burton, & Protti, 2013). The collection, storage and analysis of health data have been, are and will remain some of the fundamentals in providing efficient healthcare services and their importance is increasing in line with the growing amount of health data collected every day (Roesems-Kerremans, 2016).

5.2. Strategy

The ability to develop a strategic plan and effectively implement it is fundamental to the sustainable growth of any organization, including hospitals. HIS maturity is often measured, based on the ability to adapt to strategic changes or new opportunities. In a time of fast-paced changes and tight IT budgets, the ability to concentrate efforts on matters, which are of strategic importance to each department, sector or health organization as a whole, becomes increasingly critical. Aligning ISTs with organizational goals and strategies is a key challenge for organizations in general, and healthcare organizations in particular (Iveroth, Fryk, & Rapp, 2013). Given this line of reasoning, IT governance procedures have been incorporated, bearing in mind that IT governance allows for a strategic alignment between IT and the business itself, promoting, among others, greater transparency, increased data quality to support strategic decisions, an improved use of technological resources, the optimization of IT-related costs, and the controlled management of IT-related risks and opportunities.

5.3. People

People play a central role in health organizations and are, more than ever, becoming a differentiating factor, assuming an increasingly relevant position in their growth and development strategies. Indeed, health organizations have been pushed towards modernization where people management is concerned, as they encompass a wide scope of service/system users. Depending on how services are configured, health processes may include patients, health professionals (such as medical specialists, nurses and radiologists) and IST professionals, among others. In this sense, the characteristics of this influencing factor refer to aspects connected with the management of IST professionals; furthermore, in their approach to health professionals and patients, they aggregate characteristics connected with system usability.

5.4. Electronic medical record

The adoption of an electronic medical record system is a primary goal of modern health organizations, as it is mainly intended to improve their effectiveness when treating patient information and making it available in a timely and accurate form at the point of service (Priestman, 2007). In terms of maturity, as the system progresses to its final stage, more and more information will be made available via traditional computers, mobile phones and other mobile devices. This system works as the main source of all information pertaining to the patient, offering a complete medical record that should be available both *online* and when in human contact with the patient. This influencing factor has several characteristics and/or different cumulative functionalities needed to build a complete and exhaustive electronic medical record for the patient.

5.5. Information security

The main goals of data security are confidentiality, integrity and availability. However, safeguarding these goals does not translate automatically into security measures for health organizations. Security is achieved by simultaneously preventing attacks against ISTs and guaranteeing that the mission of the organization is fulfilled, despite attacks and accidents (Saleh, 2011). Indeed, security issues in organizations stem from the fact that security is often addressed on an individual basis and without any reference to business goals. The characteristics of this influencing factor take this reality into account in the course of its six maturity stages.

5.6. Systems and IT infrastructure

According to Galliers and Sutherland (1991), internal systems or processes are used to support and implement the strategy and the

Table 5
HISMM maturity model.

	Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI
Data analysis	• Isolated and fragmented data analysis solutions • Heavy and complex production of internal and external reports • Data integrity issues • Inability to handle large volumes and variety of data • Problems when collecting data from different systems • Lack of analytical and IT resources • Use of spreadsheets and local database	• Key data collection and integration • Centralized data repositories • Automated production of internal reports • Automated production of daily metrics available on BI platforms • Daily productivity is automatically estimated and delivered to managers • Ability to drill down from a summary to the particular conditions of the patient	• Efficient and consistent report production and adaptability to changing requirements • Decreased variability in healthcare processes and increased focus on internal optimization and waste reduction • Senior managers monitor productivity in terms of staff and combination of skills • Department managers monitor daily productivity results on their dashboards	• Patient care is adjusted, based on metrics • Final users have started to incorporate analytical patient data, including big data, in operations and daily tasks • Costs and quality are monitored via organizational performance dashboards • Financial results and clinical patient data form a competitive advantage to increase profit	• Organizational processes for intervention are supported by predictive risk models • Clinical risk intervention, modelling and predictive analysis • Full integration of service line data in the strategic planning process • Existence of an Analytics Ecosystem that supports innovation and data exploitation • Clinical outcomes screened with data warehouses and big data sources • Alarm management or clinical data intelligence production	• Adoption of personalized medicine and prospective analyzes • Patient care adjustment based on population results and genetic data • All valuable data are available for analysis and exploration • Real-time data are used in critical activities, such as patient care • Internal and external data sources to improve and optimize costs and quality • Permanent data analysis mentality and culture
Strategy	• There is no global strategy for IS/IT • There is no formal strategy • Ad hoc strategies adopted by different IS sub-areas to answer isolated problems and needs • IT governance processes are not enforced and the organization does not recognize their need	• Development plans in silos and static structures • Lack of understanding of how to achieve success • The impact of high-level strategies and goals is not mapped • Strategic planning has little impact on day-to-day operations, budgets and resources • Individuals are left on their own to interpret goals, strategies and priorities • IT governance processes are casual and uncoordinated	• Plans are shared between silos • Different plans with a shared impact are aligned • Low prioritization between groups for high-level projects, goals and plans • There is a measuring tool (although minimal) to assess success and/or impacts • A formal strategy with a technology-centric tendency • IT governance processes follow a regular path	• Strategic plans share a common format • Strategic plans are shared with other strategic initiatives • Available metrics measure the impact of high-level goals in each programme • Projects are prioritized based on impact and alignment with established goals • Increasingly inclusive planning for all groups, plans and strategies • IT governance processes are documented and reported	• A specific group reviews goals and measures progress • Strategic goals become managed programmes • The strategy is regularly reviewed and updated • Funding processes are aligned to support strategic goals • Faster and more efficient planning and impact analyzes • Evolution strategies based on new opportunities and developments in the sector • IT governance processes are monitored and measured	• Plans are agile and interactive • Plans to change impacts are understood and shared with other plans • Projects and costs are measured against strategic goals • Metrics support decision-making processes connected with goals and forms of achieving success • A strategic review involves all stakeholders for more comprehensive initiatives • Best IT governance practices are followed and automated
People	• Inconsistency when performing existing practices • Lack of responsibility and capacity of managers/staff • Practices based on customs and habits • Teams lack emotional involvement • Lack of awareness about the relevance of usability • No initial training plan according to the type of user • Individualist attitude among ICT professionals	• Enforcement of a basic set of people management practices • Adoption of communication and coordination procedures • Introduction of performance management • People receive training • Existence of continuing training plans by type of user • The IS/IT team may receive some training in usability, although this is provided during work, rather than as a formal process	• The development of an infrastructure to increase workforce capacity • Analysis and development of skills • Human resource planning • Recognition of the usability value • Internal awareness programmes on usability	• Previously implemented work practices are now standardized and adjusted • Development of careers, work groups and practices, based on skills • Participatory culture • Integration of skills at work • A small team with usability-related responsibilities • Formal training to expand usability skills • Sharing expert staff with other health units	• Autonomous work groups • Quantitative management of performance and measured practices • Management of organizational capability • Guidance and counselling • All usability benchmarks are implemented, including the existence of a team focused on user experience • Staff are trained and know how to apply best practices when developing assessment systems for internal and external use • Healthcare professionals must participate in the definition/design of their clinical pathways	• Continuous improvement in individual and work group skills • Work groups are aligned with organizational capability/performance • Continuous human resource innovation • Business benefits are understood, usability is completely acknowledged, and the results are strategically used by the organization • Ongoing integrated development training for teams • Users are trained/encouraged to learn new skills

(*continued on next page*)

Table 5 (*continued*)

	Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI
Electronic medical record	• Patient clinical data are administrative only • Independent client management and departmental systems • Primary records and clinical images in microfilm or paper formats • Requires access to paper-based systems because not all repositories are electronic • Relies on statistical formats • Content is kept in separate repositories • There is no master patient Index system	• Integrated clinical diagnosis and treatment support • Integrated use of master patient index with departmental systems to organize content • Early PACS and ERP integration • DICOM images are accessed via separate repositories • Basic scanning of medical records in selected areas only • Record management for physical content only • Electronic integration with administrative systems • Administrative capabilities in resource management, electronic discharge submission, treatment schedule and electronic claims/payment processing	• Clinical activity support • Clinical documentation includes electronic clinical order, report results, prescriptions, multi-professional care • PACS available outside radiology • Medical record recovery (EMR, ECM, DICOM) through portals • Limited EMR and DICOM integration with heavy reliance on unstructured content • Limited electronic record management • EMR with limited interoperability • CIS, LIS, RIS, PACS and medication/pharmacy management systems are implemented	• Adoption of clinical knowledge and decision-making support • Electronic access to guidelines, rules alerts and support systems • Closed-circuit medication administration • Large-scale PACS dissemination and communication • Internal portals used to access repositories with relevant contents, such as EMR and PACS • EMR connection with automated ID, barcodes and OCR for image captioning • Static forms replaced by e-forms • Integrated CPOE with billing system	• Medical documents based on structured templates • Outpatient and inpatient regimes • PACS process innovation • Complete PACS and patient medical record integration • Integration of specialized medical modules	• Fully electronic medical records for all areas • Complete recovery of medical records through an EMR-based portal • Adoption of mobile telemedicine and wireless access to clinical data • Patient records become a collaborative tool • Complete point-of-care data (tablet, voice or workstation) • Management of audit requests, incidents and investigations • Content organized to support results-based analyzes • Use of BPM for cross-functional processes • Medical record use by several healthcare providers
Information security	• Absence of policies to ensure IT/IS security • Investment in security systems is not a priority • The impact of vulnerabilities is not evaluated	• Early stage of conformity • Lack of policies and procedures defined to protect the organization • No contingency plan in crisis situations • Reactive and unplanned security control • Goals change in response to attacks with the implementation of some type of protection	• Applications and network security are implemented • Changes are not managed in a centralized way and security requests are performed ad hoc • Goals focus on business activities of the organization and the protection of central systems • Systems are falsely perceived as being protected • Unique credentials for portal access	• Security awareness programmes are adopted only for key resources • IT security procedures are formally defined • Responsibility for IT security is assigned, but execution is inconsistent • Ability to perform some penetration and detection tests • Closely monitored and mandatory access controls	• Centralized management of security-related issues and policies • Users are reliable, although system interaction is perceived as a vulnerability • No ad hoc changes • Implementation of central configuration models, from which all settings are derived • Security policies and procedures are in force • Identity management of in/out professionals	• Formal policies and procedures to prevent, detect and correct security problems • Corporate governance aligned with security needs • Internal audit policies with published results and implemented actions • Identification of security issues/incidents is systematically monitored • Notification system for security incidents • Email filters and intrusion detection systems are used
Systems and it infrastructure	• Uncoordinated and unconnected systems with limited applications • LAN infrastructure • Key financial and administrative systems are implemented • Infrastructural management is manual, unarticulated and ad hoc • At this level, IT focuses on downtime avoidance • Lack of monitoring causes reactive and ad hoc procedures • Unpredictable service performance • Lack of interoperability awareness and supporting processes • Usability focuses on products and processes, rather than on people	• Internet-based infrastructure with HIPAA • Manual, yet coordinated, infrastructure management • Knowledge storage in silos • Services are managed and predictable • The organization is focused on obtaining infrastructural control • Interoperability solutions are firstly applied in clinical/administrative areas • Product and service usability focused on users • Sporadic incursion in usability practices with limited resources	• Communication infrastructure based on Secure HL7 • Infrastructure for collaboration and knowledge-sharing • Reactive, yet becoming proactive • Stable IT infrastructure • The organization recognizes the importance of adopting norms and best practices	• Cooperative infrastructure involving medical communities • Adoption of electronic prescriptions • Implementation of international coding of diseases, alerts/contraindications for educational purposes • Incorporated nursing documentation system • Management of the emergency and cardiology departments • Interoperability guidelines defined for healthcare norms, services, policies, processes and legal compliance	• Fully connected and paper-free infrastructure (SaaS model) • Physician portal and patient portal • Wireless infrastructure • Available processing data tools for research purposes • Consolidated infrastructure level with OaaS model and RaaS model • Knowledge-sharing and collaboration inside the team • Proactive infrastructure and continuous service improvement • Interoperability assessment processes	• Infrastructure in a regional/national network connecting all service providers • Aggregate data from all hospitals and regions enable governmental healthcare planning initiatives • Remote patient monitoring and telemedicine • Continuously improving interoperability capability based on monitored process feedback • Focused on becoming a catalyst for innovation • Infrastructure for knowledge-sharing and business collaborations, both internal and external • IT/IS and healthcare stakeholders work as a team

regular operations of an organization, as well as designed to be strictly followed in order to achieve maximum efficiency. As in other activity sectors, hospitals must resort to ISTs and their IT infrastructure to support all their activities, both inside the hospital environment and where different health field partners are involved (Mikalef & Batenburg, 2011). Similarly, Sharma (2008) states that the system connected with the health care process can be defined thus: "*A set of activities, methods, practices that people use to provide healthcare services and maintain the environment that supports the service providers*" (p. 2). This environment involves both the medical devices and the healthcare entities associated with supply and, fundamentally, the IT infrastructure.

6. Results and contributions

Based on the research questions and goals established for this project, the results and contributions essentially provide greater knowledge about the maturity models in the health field, which are expected to promote an improvement in practice related to HIS management.

Regarding the first research question (RQ1), which is related to the identification, proposal, and description of a list of the most important maturity-influencing factors associated with the early maturity stages of an IS in the health field, the conducted research identified 12 such factors. These factors emerged from an extensive and structured review of the literature on maturity models in the health field. These factors were proposed during the study by means of a questionnaire-based survey. The opinions of the experts participating in this study allowed us to classify the most important maturity-influencing factors, which in turn helped to extend the knowledge in this area. After a statistical analysis of the data, it was found that the six highest-ranking factors in terms of importance could be designated as the most important maturity-influencing factors for maturity models in the health field. As mentioned throughout this article, one of the main problems faced by HIS managers is knowing which sub-areas in their respective departments have greater relevant and, for this reason, should be the subject of priority investment. In this sense, the list of the most important maturity-influencing factors proposed here may represent an important starting point for HIS managers who do not know where to begin.

Another contribution relevant to this first research area is the fact that the main maturity-influencing factors are susceptible to the evaluation of maturity in the context of HIS maturity stages (RQ2). In fact, the results of the studies performed are unequivocal. According to the questionnaire-based survey (to which 46 specialists in the HIS management field responded), in which the main maturity-influencing factors had rates of acceptance near to 100%, and the interview survey (conducted with five important managers in various groups of Portuguese hospitals), there was unanimous recognition that the main maturity-influencing factors could be evaluated according to their maturity level. The recognition of this fact is an important aspect, which can help HIS management to determine at what stage their different sub-areas find themselves, as well as what steps to take for them to evolve into maturity.

Even when it comes to the contributions made in relation to the research questions, it can be concluded that both RQ3 (i.e., can a HIS take on different maturity stages, taking into account the different maturity-influencing factors?) and RQ4 (i.e., can a comprehensive maturity model be used in the evaluation of the HIS maturity level, taking into account the weighting of the importance of the different maturity-influencing factors?) prompted categorical responses from the interviewed managers. We can thus conclude that a HIS can be found at different maturity stages, when taking into account the different sub-areas involved, while the assessment of HIS maturity must consider the weighting of the importance of these different sub-areas. The answers to these questions are considered to be particularly useful for HIS management because they reinforce the view that making a general assessment of the HIS maturity, without considering the diversity of the respective sub-areas, is obviously narrow and could lead to misinterpretations.

The second set of contributions resulted from the literature review and consisted of the identification and synthesis of a set of maturity models of healthcare information systems. This synthesis work revealed and confirmed the embryonic stage at which the development of maturity models is found, especially in the health field. Fourteen identified models were analyzed, with the results showing how difficult it is to identify a maturity model that is comprehensive enough to encompass all the sub-areas of a HIS when an evaluation of overall maturity is required (Carvalho et al., 2016b). The lack of a consensus on the identification and weighting of the influencing factors, which can measure overall maturity is latent; for that reason, we argue that our HISMM proposal represents a valuable contribution in closing this particular gap.

7. Limitations and further research

Despite its contributions, this study includes a number of limitations, some of which should prompt further research. One of the main limitations of this work is related to the description and characterization of the 12 maturity-influencing factors, which made up our initial list. Although this work constitutes, as mentioned, a contribution that may be useful for HIS management, it is recognized that this description presents some limitations because it is supported by the review of the literature on health maturity models. In order to overcome these limitations, an empirical validation would have been important, especially if it has been performed in a HIS.

A second limitation is related to the fact that the five interviews involved HIS managers, four of whom were from public hospitals (i.e., only one worked in a private hospital). In addition, the managers involved were all Portuguese, meaning they had a circumscribed perspective of the reality of health in Portugal. Applying our HISMM to a great number of hospital cases, even in other countries (e.g., in the rest of Europe) is needed to further validate and enhance its current base. Furthermore, a larger sample of health institutions would provide more robust results and enable cross-country comparisons, as well as identify cultural differences.

Third, in this study, we did not specifically measure hospitals' HIS maturity nor identify improvement opportunities. For that matter, we also did not relate such a maturity measurement to hospital performance or IST performance within the hospital. This would be a valuable research opportunity, as HIS maturity could be conditioned by certain contextual and organizational aspects. Finally, we did not address how hospitals might use this model to align ISTs within the hospital enterprise and account for optimal diffusion within the organization (van de Wetering, 2016).

Another future piece of work could involve the development of an automatic tool for assessing HIS maturity. This tool should be built, based on the principles established in relation to our HISMM, and allow for the assessment of both influencing factors and general HIS maturity. This general maturity should be calculated on the basis of a formula, which considers the relative weight of each influencing factor. In addition, this automatic tool should reflect the procedures that a certain HIS should adopt in order for its maturity to evolve. The tool should be made available on the Internet, enabling managers to perform HIS maturity assessments and simultaneously make comparisons with their competitors, as well as understand the evolution of their maturity over time.

8. Discussion

Maturity models, which support decision makers in the process of improving health systems and facilitate major organizational, procedural and clinical transformation, are very valuable. However, the extant literature on empirically validated IST maturity models is limited, particularly concerning models in the healthcare context. In this paper,

we proposed a HISMM, based on a mixed methods approach and informed by the IST maturity model literature, along with associated evolutionary stage characteristics.

The outcomes of this work suggest that the designed and empirically validated HISMM, which includes six stages of HIS growth and maturity progression, enables both the assessment of the global maturity of a HIS and the individual maturity of its different weighted dimensions. This extends the currently available literature on health ISTs. Our results also complement and confirm previous study findings that IST can be beneficial for hospitals in terms of performance gains and enhancements (Buntin et al., 2011). The HISMM, as an artefact, also represents a practical application for decision makers in the process of situationally setting goals and systematically enabling a HIS to evolve towards higher maturity levels. This process can now be supported by the HISMM architecture, which includes various comprehensible evolutionary stages with associated measurable indicators. The HISMM can be applied to a wide variety of conditions and circumstances, i.e., hospital decision makers can now use the maturity model to (1) define the current maturity stage, (2) determine the next achievable maturity stage and, finally, (3) identify the attributes that must be met in order to reach a new maturity stage and meet the respective hospital's ambitions and goals.

Stage-based maturity models are often criticized for being overly simplistic in nature (King & Kraemer, 1984). In principle, this current empirically validated model provides all the necessary means by which to evolve through the different maturity levels and understand what the considerations are at each level. HIS implementations can also be evaluated, while their different stages of maturity can be determined by taking into account their different sub-areas. As such, the HISMM allows for situational routes and improvement road maps, thereby avoiding the linearity pitfall of most stage-based models in order to achieve the strategic direction of the hospital. Currently, hospital decision makers are under pressure to reduce operational costs, while simultaneously improving their hospital's efficiency and effectiveness using costly ISTs. It is within this process that they should manage the implementation, adoption and acceptance of new digital technologies within the hospital enterprise. Our HIMSS model is, therefore, a promising route by which to address the many challenges that hospitals face.

9. Conclusion

The present paper has presented the reasons underlying the development of an encompassing maturity model for the healthcare field. The HISMM was developed to address HIS complexity and propose a useful tool for the demanding role of HIS management. This model was developed in line with the methodological procedures for creating maturity models, with a view to guaranteeing its recognition, solidity and relevance, both in the academic field and in society as a whole. To validate the HISMM, we interviewed a diversified group of IS managers from Portuguese hospitals. The results of this investigation have been encouraging, while revealing a high level of acceptance among the interviewed managers. This early acceptance pushes us towards the development of a new model stage, focused on the development of an automatic HIS maturity assessment tool.

Annex A. Guide to the interview

1. Purpose of the interview, that is, “to help to complete and validate a comprehensive maturity model for hospital IS management”.
2. Explain the interview model, with audio recording for later analysis, ensuring anonymity and safeguarding the authorization of the disclosure of the answers after the interview has been transcribed on paper.
3. Characterization of the professional career, the characterization of the hospital unit and, fundamentally, the managers' opinions about their IS experience and maturity models.

Category	Topics	Questions
Professional background	Characterization of HIS managers	What is your academic background?
	Understand their academic background and experience in the IST area	When did you start working with the HIS?
		When did you start your CIO function?
	Understand their experience as a Hospital CIO	Did you have difficulty adapting to the duties that the position demands? If so, why?
Hospital	Characterization of the hospital unit	What is the number of beds and the number of employees?
	Identification the size of the unit	What is the number of professionals in the IST area?
	Identification of the IS department	When was the IS department formally established?
IST maturity	Manager's knowledge of the maturity concept	From your point of view, what are the characteristics that an HIS must have to be considered an excellent HIS?
	Manager's preferences regarding the best maturity model	When you talk about the maturity model concept, what happens to you?
	HIS aspects that the maturity model must address	There are several maturity models. What kind of maturity model would you prefer to use?
	Tool or technique adopted to measure HIS maturity	If there is a maturity model that can be used to evaluate the maturity of your HIS, what are the main aspects that the model needs to address?
	Importance of maturity assessments of different IST sub-areas	Do you use any technique, tool or method to measure IS maturity? If so, which one?
	Identify the most important sub-areas for the evolution of HIS maturity	Do you have any idea of the level of maturity of your IS? If so, what is the maturity on a scale of 1 to 6?
		Do you think it is important to use an automatic tool to evaluate IS maturity?
		Do you consider it only necessary to know about general IS maturity or more important to know the different levels of maturity in the different IST sub-areas?
		What are the sub-areas of your IS that are at a more advanced stage? Which sub-areas of your IS are at an earlier stage?

	What characteristics, procedures or technologies do you consider important to implement for your IS maturity to evolve?

4. Presentation of the HISMM, together with its building blocks (i.e., stages, influencing factors and characteristics).
5. Describe the research methodology followed in order to inform the managers of the context in which the model was developed.
6. Invite managers to judge whether the set of influencing factors for the model is the most appropriate for a HIS.

Category	Topics	Questions
Model structure	Level of agreement with the Influencing factors of the model Possibility of evaluating the influencing factors Weighting of the maturity of the different influencing factors in the global evaluation of HIS maturity	Do you agree with the model's influencing factors? Would you add any other influencing factors, which you consider relevant and cannot be incorporated into existing ones? Do you consider that all the influencing factors of the model can be evaluated in terms of their degree of maturity? Can the comprehensive maturity model be used to assess the level of maturity of a HIS considering the importance of its different sub-areas?

7. Ask the managers about the characteristics that exist in each sub-area of their HIS, and those they would like to implement.
8. Question the managers about any possible omissions or additions regarding the list of characteristics of each influencing factor in the framework of the model.

Category	Topics	Questions
Data analysis Strategy People Electronic medical record Information security Systems and IT Infrastructures	Understand the opinion of the manager regarding the evolution of the characteristics of this sub-area in the past Understand the manager's vision of the most important characteristics to be implemented in this sub-area Validate the characteristics of this sub-area in the model	What characteristics do you recognize in your HIS in the context of this sub-area? What characteristics do you aspire to implement in this IS sub-area in order to improve it? With regard to the characteristics listed in the model, which ones do you agree with and which do you disagree with? For this sub-area, would you add any characteristics to the different stages of the model? Would it change any of the characteristics?

9. Finally, the interview ends by discussing the possibility of a pilot evaluation of maturity (in the near future), given that the updated model, based on suggestions for improvement from the managers, would be converted into an automatic maturity evaluation tool.

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