

HIGHLIGHTING THE IMPORTANCE OF BUSINESS INTELLIGENCE MATURITY MODELS IN THE HEALTHCARE SECTOR

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Abstract

The digital transformation associated with the huge volume of data that healthcare organizations deal with, nowadays, are on the basis of transforming this complex knowledge-driven industry to transform data into knowledge. The healthcare industry requires comprehensive models to help identifying the priorities to implement a Business Intelligence (BI) solution.

Business Intelligence can help organizations make better decisions by showing present and historical data within their business context.

In the recent digital transformation, the decision process is supported through data analysis. Established as a common denominator, small and large organizations transform their data into valuable knowledge and powerful capabilities to help them become more data-driven organizations. To become a data-driven organization means that organization leaders/managers make decisions supported on the data that is setting in the organization. The decision support systems together with technology helps the decision makers to gather insights to enhance organizations.

This paper presents and highlights a comprehensive review of existing healthcare maturity models and tries to identify the main features of the presented models as well as the common success factors in adopting a Business Intelligence Maturity Model in Healthcare organizations.

Keywords: Business Intelligence; Maturity Models, Healthcare; Healthcare Business Intelligence Maturity Models

INTRODUCTION

In a hospital organization, most of the data comes from the medical activity and all the processes related to organization management. All this data is transformed into useful clinical information and then provided to the various parties involved, such as patients, doctors, managers, government, and other employees of the organization (Binoti, 2019).

In the healthcare area, the quick growth of Information Technologies has had a particular and striking impact as it has led to an urgent need to improve the healthcare provided to the population (Correia & Silva, 2019).

Maturity models are based on the premise that people and organizations evolve through a process of development or growth towards a more advanced maturity. The higher the level of maturity, the greater the organization and the effectiveness of a company. These models are also used in healthcare organizations (Rocha & Vasconcelos, 2004).

The success of Business Intelligence systems in the organization depends on a series of factors related to the work environment and its culture, and all these factors constitute the maturity of the project. Currently, Business Intelligence presents itself as an area of great growth and high funding by organizations, presenting itself as a decisive role in creating competitive advantages

(Corte-Real, 2012).

As health organizations continue to be asked to do more with less, access to information is essential for evidence-based decision-making. The use of technology to help ensure the quality of healthcare and cost reduction is a constantly evolving theme of study (Ashrafi, Kelleher & Kuilboer, 2014).

Through Business Intelligence, healthcare organization can have the potential to improve methods and processes that support the individual's health, promote better operational performance, and provide more and better quality, cost savings and patient involvement (Gomes & Romão, 2018).

The remainder of the paper is organized as follows: Section 2 describes what Business Intelligence is and presents a Business Intelligence framework. Follows Section 3 that reports the use of Business Intelligence in the healthcare domain and the next section justifies the advantages and barriers to the use of Business Intelligence systems in the healthcare domain. Section 5 introduces maturity models and section 6 shows three Business Intelligence healthcare maturity models. Section 7 summarizes the core of the present work, that is to identify the stages involved healthcare maturity models. Finally, some conclusions are point out on section 8.

BUSINESS INTELLIGENCE

The term *intelligence* has been used by researchers in the field of Artificial Intelligence since the mid-1950s. In turn, Business Intelligence emerges as a popular concept years later, in mid-1989 originally defined by Howard Dresner, as "concepts and methods to improve business decision making by using fact-based support systems."

For Sezões, Oliveira & Batista (2006), Business Intelligence covers a wide range of decision support applications with fast, shared, and interactive access to information, allowing easy data analysis and modification of data.

Business Intelligence systems usually occupy a strategic position in organizations and are implemented with the objective of improving the weak management reports released by operational systems. These systems aggregate a set of technological resources and allow interactive access to data, often in real time, providing the organization with the ability to perform appropriate analysis (Pastori, 2012).

The concept of Business Intelligence is a broad and generalist concept, with several business processes, software applications and specific technologies. The Business Intelligence environment allows transforming raw data into relevant, accurate and useful data. It also helps the decision maker to convert them into quality information for analysis or decision making, with greater speed and security.

One of the main objectives of a Business Intelligence system is to support decision making. The knowledge produced by Business Intelligence systems, leveraged by today's communication technologies, supports, and justifies the measures taken by the various stakeholders in the decision-making process (Sezões, Oliveira & Batista, 2006). Through Business Intelligence systems it is possible to locate potential revenues, discover new market trends and discover new business opportunities.

In order to understand how a Business Intelligence platform works, Figure 1 presents a generic structure divided into three distinct areas: Data Source, Data Warehouse & Storage and Presentation.

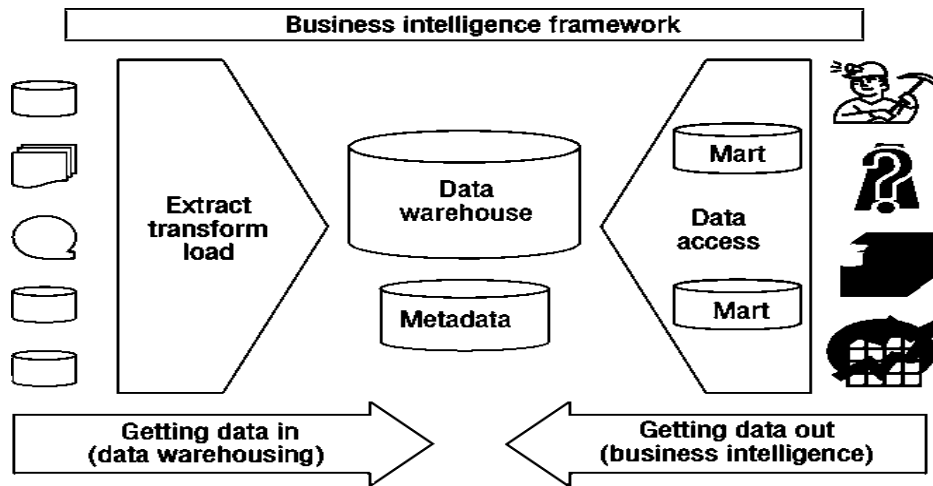


Figure 1. General architecture of the Business Intelligence process. (Watson & Wixom, 2007)

The Data Source area contains all the data sources that will support the Business Intelligence system. Data sources may be internal and/or external to the organization (Leite, 2018). The internal data comes from the operational systems, e-mails, ERP systems, etc. The external data is provided from news, blogs, tweets, government policies, etc.

The Data Warehouse & Storage area is responsible for the whole process of Extract, Transform and Load (ETL) using tools appropriate for the treatment of data, which come from several sources, in order to integrate them, transforming them and loading them into the appropriate data repositories (Leite, 2018). The first step is to extract data from the several and different sources that feed the Data warehouse and come from the traditional transaction processing systems and also from non-OLTP systems such as text files, spreadsheets, and legacy systems. The second step known as the transformation step is where the data is cleaned, corrected and aggregated, in a specific area known as the staging area. This step usually consumes a lot of time. This last part of transformation refers to the process of converting data by using a set of business rules (aggregating functions) to obtain consistent data formats for reporting and analysis. This enables the organization business logic, data standardization that guarantees data consistency across the organization. The third and last step is to load the already transformed and aggregated data into the data warehouse.

Finally, in the last area, we have the business analysis environment, where there are several front-end applications, so that managers can monitor business performance using tools such as dashboards and reports with the results obtained (Leite, 2018).

Thus, it is very important for organizations to integrate the organization available data in a Data Warehouse and transform data into valuable business information to gain competitive advantage.

BUSINESS INTELLIGENCE IN THE HEALTHCARE SECTOR

The growth of information technologies had a particular and remarkable impact in the area of health, since it led to an urgent need to improve the health care provided to the population. The use of Business Intelligence has already proven to be an effective alternative whenever real-time information is needed and whenever decision support needs to be streamlined.

Thus, the concept of Business Intelligence has been gaining more and more visibility by health professionals since this sector has been working with an increasing amount of data. Through it, access to data is made possible to help them make better decisions in a shorter period of time (Correia & Silva, 2019).

It is important to identify and define the main processes of a hospital unit, so that it is easier to prioritize information, therefore making a faster and more efficient decision (Foshay & Kuziemsy, 2014).

In the healthcare sector, the data produced come from medical activity, management related processes and other activities. All these data are transformed into clinical or financial information and provided to the various stakeholders, such as patients, doctors, managers, government, and other collaborators of the organization (Binoti, 2019).

There are several applications of a Business Intelligence system within a healthcare organization and this translates into the optimization of processes related to clinical and financial information, which allows better management of costs associated with hospitalization times, fees and even the detail of each service invoiced (Sousa, 2018).

The healthcare industry has similarities and differences with other industries. Like other industries, health care focuses on revenue, expense, utilization, and quality, but differs, as it should, in the use of information to influence the behaviour of a more diverse set of constituencies, such as doctors, patients, government, insurance companies, hospital administrators, pharmacies, and more (Ashrafi, Kelleher, & Kuilboer, 2014).

Data analysis can be used to improve many aspects of a business or organization. In the health sector, besides clinical decision support, it is also possible to improve the operational and financial aspects.

It is believed that careful and attentive use of Business Intelligence in healthcare can transform data into knowledge that can improve patient outcomes and operational efficiency (Brooks, El-Gayar & Sarnikar, 2013).

Metter and Mimarlund (2009) defined a Business Intelligence Framework where we can see the main business processes in Healthcare organizations, as shown in Figure 2.

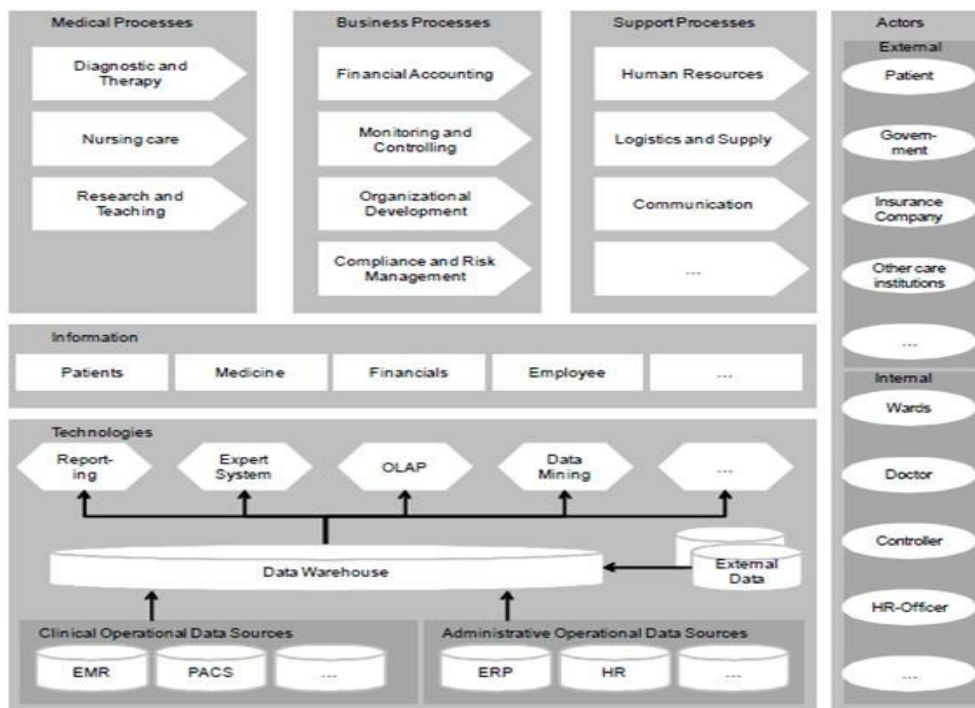


Figure 2. Main business processes in healthcare organizations. (Mettler & Vimarlund, 2009)

ADVANTAGES AND BARRIERS TO THE USE OF BUSINESS INTELLIGENCE IN THE HEALTHCARE SECTOR

Business Intelligence systems in healthcare organizations have different applications and therefore bring several benefits, both financially and in terms of healthcare services.

Business Intelligence benefits in the healthcare industry can be extend to patients, providers, and board members, and the technology can make centralized patient management a reality. As a result of this implementation, everyone from executives to managers and clinicians now have the information needed to support better decision-making on a daily basis.

According to Ashrafi, Kelleher, & Kuilboer (2014), Business Intelligence solutions can produce useful information and knowledge through existing public health data. Another benefit is that through these Business Intelligence solutions health professionals have immediate access, in real time, to the information they need, allowing the increase of quality of health services provided and, simultaneously, reducing costs.

Also, Muraina and Ahmad (2011) briefly describe the benefits both clinical and financial that a Business Intelligence system brings to healthcare organizations:

- Optimizes resources (e.g., software, human, equipment, etc.) in key services, such as surgical service;
- Develops and monitors key performance and clinical indicators, in order to increase its quality;
- Provides ability to plan, budget and forecast efficiently in complex organizations;
- Provides ability to understand and manage the supply chain and logistics in order to contain costs and always ensure products and services;
- Ensures more patient safety through efficient diagnostics and the identification and application of best treatment practices;
- Controls costs and improve performance and quality through human resources management and medical suitability of the specialty to the patient;
- Allows for information on insurance claims – information on what was done to the patient and costs associated.

A good management of the patient's health history with the use of Business Intelligence solutions, allows a more balanced patient health. In the case of chronic patients, predictive analysis help predicting the risk of rehospitalization, worsening of secondary diseases, among other situations (Hogan, 2013).

It is thanks to data mining, one of the several existing BI techniques that has great applicability in the health sector given its usability, that these predictive analyses are possible.

Regarding the difficulties in implementing a Business Intelligence system, Kaye, Kokia, Shalev, Idar, and Chinit (2010), add that the lack of transparency about the costs and benefits of implementing a BI system, both for clinicians and investors, the insufficient support and incentives for the clinicians involved, as well as their relationships with information providers, and in legal terms, the privacy of the health information involved, are factors that were not yet fully ensured.

As for the difficulties in implementing a Business Intelligence system, according to Holland (2009), the biggest obstacle was the lack of financial resources, followed by lack of human resources and, thirdly, the poor quality of the data to be analysed.

BUSINESS INTELLIGENCE MATURITY MODELS

A maturity model can be characterized as an evolution from a less orderly and less effective

state to a more orderly and highly effective state.

For Pastori (2012), a maturity model has as its main objective, to perceive what is the level of effectiveness of a certain organizational process. These models are mostly used when the investments correspond to the implementation of tools and techniques for the improvement of management processes and that deal with subjective issues, often difficult to quantify.

For Rocha and Vasconcelos (2004), maturity models are based on the premise that people and organizations evolve through a process of development or growth towards a more advanced maturity. The higher the level of maturity, the greater the efficiency of a company.

With the emergence of new technologies and new organizational methods, the concept of maturity has been widely used in organizations. It is important to discover the added value of investing in Business Intelligence through an assessment at the level of technology, processes, and organization (Côrte- Real, 2010).

To be able to balance the Business Intelligence investment with its added value, it is very important to understand the maturity of an organization, through an assessment at the level of technology, processes, and organization (Côrte- Real, 2012).

As already mentioned, maturity models help organizations to understand where they are and how they can improve. We can also understand the answers to the following questions (Rajterič, 2010):

- Where are most of the analysis of reports and business done to date?
- Which department of the organization uses the reports and analysis obtained from the BI data?
- What drives the use of BI in the organization?
- What strategies are being used to develop BI?
- What strategic and commercial value does BI bring?

MATURITY MODELS IN THE HEALTHCARE SECTOR

Business intelligence maturity models have been created to take into consideration the technology and data needs of an organization to make solid business decisions.

The fast development of hospital organizations over time and the rapid technological evolution have led to a phenomenon of change that emerges with the aim of correcting the mistakes made and improving the care provided. Several information systems have been implemented in order to improve this situation.

Maturity models are used to describe, explain, and evaluate the life cycle of something. The basic concept of all models is based on the fact that things change over time and that most of these changes can be predicted and regulated (Rajterič, 2010).

It quickly became apparent that this implementation could be monitored, making it possible to determine how a given organization could improve (Rocha, 2011).

The maturity models applied to health information systems are special because they must consider all medical procedures and information important to the clinical process (Correia & Silva, 2019).

Brooks, El-Gayar & Sarnikar (2013) have developed six requirements for the establishment of a Business Intelligence maturity model for the healthcare sector:

- Establish a responsible department to manage the Business Intelligence system;
- Determine and focus on operational, financial, and clinical information needs;
- Consider the specific processes of the organization and capture the key processes and practices of Business Intelligence;

- Incorporate key processes that include the people, technology, and processes of the organization;
- Incorporate quality aspects, including system quality, information quality, and service quality;
- Provide an understanding of the relationships between the different levels and key processes involved in the maturity model.

In the next section, we will detail four healthcare business intelligence maturity models, highlighting what distinguishes them, while also highlighting their different stages.

The first stage usually called the initial stage, indicates an organization with very few or non-capabilities in the domain showing very low maturity. The higher stage represents an organization with total maturity in the specific domain being organization wide-focus, proactive, innovative and very efficient resourcing.

Adoption Model for Analytics Maturity

The Healthcare Information and Management Systems Society is a US non-profit organization dedicated to improving healthcare in terms of quality, safety, cost-effectiveness, and access through better use of technology and information systems.

Aiming to advise leading global organizations interested in what are the best practices in health information and technology, this organization drives key data resources, guiding operations and clinical practice through predictive analysis tools and maturity models. HIMSS Analytics is a research and analytical branch of HIMSS, responsible for collecting, analyzing, and distributing data. It is also responsible for developing seven different maturity models.

The Adoption Model for Analytics Maturity (AMAM) is designed to measure and improve the analytical capabilities of an organization, and although it is a normative model in the competencies considered essential, it recognizes that each organization is unique and therefore provides flexibility regarding the achievement of the objectives outlined (Correia & Silva, 2019).

In order to better understand how the different stages of this model work, Table 1 presents the most important factors of each stage divided into three distinct areas: Technology, Process and People.

Table 1. Adoption Model for Analytics Maturity (HIMSS Analytics, 2018)

	Technology	Process	People
Stage 0	Data distributed in spreadsheets.	Paper-based processes.	Desire to learn about analytics capabilities.
Stage 1	Organizations are just beginning to have a data centralized location.	Data Repository.	Data governance.
Stage 2	Data Warehouse.	Basic clinical and operational tasks.	Analytic skills, standards, and education are managed through an analytics competency center.

Stage 3	Data warehouse access is managed and reliable.	Data quality is stable and predictable. Tools are standardized and broadly available.	The different parts of the organization are able to work with the data.
Stage 4	Analytical data assets, skills, and infrastructure.	Improve clinical, financial, and operational program areas.	Effort to understand and optimize by improving the organization's critical analytical resources.
Stage 5	Point of care-oriented analytics. Summarization and mapping of patient data.	Quality based performance reporting.	Data governance is aligned to support quality-based performance reporting.
Stage 6	Advanced data content and clinical support.	Predictive analytics.	Completely engaged as a data-driven culture.
Stage 7	Personalized medicine.	Specific patient care and prescriptive analytics.	

Electronic Medical Record Adoption Model

Understanding the level of Electronic Medical Record (EMR) capacity in hospitals is a challenge in the context of modern-day healthcare (Rocha, 2011).

Healthcare has gone through three phases of computerization and data management: data collection, data sharing and, more recently, data analysis. The data collection phase is characterized by the implementation of electronic medical records (EMR) (Carvalho, Rocha & Abreu, 2016).

The Electronic Medical Record Adoption Model (EMRAM) consists of an eight stages model that allows following the progress of the organization to be evaluated, in relation to other health care organizations in Europe and around the world (Correia & Silva, 2019).

In order to better understand how the different stages of this model work, Table 2 presents the most important factors of each stage divided into three distinct areas: Technology, Process and People.

Table 2. Electronic Medical Record Adoption Model (HIMSS Analytics, 2018)

-	Technology	Process	People
Stage 0	Spreadsheets.	Some clinical automation may be present.	Desire to learn about analytics Capabilities.
Stage 1	There is not a data centralized location.	Major clinical systems are installed. - laboratory, pharmacy, and radiology.	Lots of data useable for functional processes only.

Stage 2		Accumulate and manage data into the CDR.	Limited capacities to analyze data.
	Data centralized location - Clinical Data Repository (CDR).		User interface capable for reviewing all orders, results, and radiology and cardiology images.
Stage 3		50% of documentation is implemented with the CDR.	
Stage 4	Computerized provider order entry (CPOE). - Designed to replace a hospital's paper-based ordering system.	50% of all medical orders are placed using CPOE.	Access to a national or regional patient database.
Stage 5	Data is available for at least 50% of the hospital - progress notes, consult notes, discharge summaries, problem/diagnosis list, etc.	Track and report on the timeliness of nurse order/task completion.	People have limited access to the data.
Stage 6	Advanced data content and clinical support.	Closed Loop Medication Management (CLMM). - fully electronic medication management process.	Completely engaged as a data-driven culture.
Stage 7		Complete use of the CDR.	

Healthcare Analytics Adoption Model

According to Sanders, Burton & Protti (2018), it is necessary to invest in solutions associated with data analysis and the use of databases. In this sense, the Healthcare Analytics Adoption Model (HAAM) was developed to accelerate the advance of maturity analytical data in health care organizations. This model is used to measure the adoption and use of data storage and data analysis in healthcare.

In order to better understand how the different stages of this model work, Table 3 presents the most important factors of each stage divided into three distinct areas: Technology, Process and People.

Table 3. Healthcare Analytics Adoption Model (Sanders, Burton & Protti, 2018)

-	Technology	Process	People
Stage 0	Internally developed applications.	Paper-based and spreadsheets processes.	No formal data governance.
Stage 1	Limited data are co-located in an Enterprise Data Warehouse.	Collecting and integrating the core data content.	Senior executive starts to see the functional use of analytics in the organization.

Stage 2		Relating and organizing the core data content.	Data governance and master data management.
Stage 3 and 4		Efficient, consistent production of reports and widespread availability in the organization.	An analytic services user group exists that facilitates collaboration between corporate and business unit data analysts.
Stage 5	Evidence-based and standardized data marts.	Measuring adherence to clinical best practices, minimizing waste, and reducing variability.	Data governance expands to support multidisciplinary care management teams.
Stage 6	Sustainable data driven culture.	Maximizing the quality of individual patient care, population management and the economics of care.	Through data reports, a senior executive is accountable for balancing cost and quality of care.
Stage 7	Predictive analytics.	Organizational processes for intervention.	Completely engaged as a data-driven culture.
Stage 8 and 9	Shift from a fixation with care delivery to an obsession with risk intervention, health improvement and preventive medicine.	Personalized medicine, prescriptive analytics, direct-to-patient analytics & artificial intelligence.	

A SYSTEMATIC REVIEW OF BI MATURITY MODELS IN THE HEALTHCARE SECTOR

During the research work, three different maturity models were deeply studied. After analyzing each one, they were summarized in the following table, highlighting the components that were considered most essential and common.

In order to better understand what these models all have in common, Table 5 presents the mutual factors of each stage divided into three distinct areas: Technology, Process and People.

Table 4. Systematic Review of BI Maturity Models in the Healthcare Sector

	Technology	Process	People
Stage 0	Data distributed in spreadsheets, ad hoc databases, inconsistent data, poor data quality	Basic organization processes.	Unaware of data or little awareness of or interest in data or analytics. Lots of data useable for functional processes only.

			Senior managers do not discuss data management.
Stage 1	Islands of dispersed Data and technology: Data stored in ERP systems or similar. Access to the data is protected. Poorly integrated systems.	Ad-hoc or specific oriented processes.	People have controlled access to the data and have permission to store and access appropriate data according to their business functions.
Stage 2	Existence of a Data Warehouse.	Processes are organized with clearly defined roles and responsibilities.	A data analytics team is created with well-defined roles and responsibilities (governance).
Stage 3	Full use of a Data Warehouse capabilities including OLAP analysis.	Processes are well defined and exists a clear communication between technology and business rules. Including Internal and external reporting to improve clinical areas and practices.	Senior leaders start to recognize the importance of data analytics.
Stage 4	Data mining - enhanced decision-making tools.	Clinical support and quality metrics are implemented to capture insights from organization business processes.	Data driven decision making with data governance.
Stage 5	Data Mining, Artificial Intelligence and Big Data – enhanced decision-making tools.	Clinical support and quality metrics are implemented to capture insights from organization business processes.	Senior leaders view data as a strategic asset aligning analytics with business processes.

Regarding the number of stages, there are models with seven to nine maturity stages, and they all have been developed to fulfill the same function: improve the organizational structure and the training of health organizations. It can also be concluded that the highly specialized maturity models have resulted in a health subsystem.

None of these three models has been published in newspapers of research systems. As they have all been published in "white papers", it becomes impossible to prove their validity in the context of peer review as stated by Carvalho, Rocha & Abreu (2016).

CONCLUSIONS

The development of a Business Intelligence maturity model for healthcare organizations

provides great contributions to the information and knowledge of the organization's management. Business Intelligence offers breakthrough possibilities for new discoveries, better patient care, and greater efficiency in health and healthcare, innovate and research to enhance patient care effectively, optimize operations, among others.

We can conclude that Business Intelligence Maturity Models have been created to take into consideration the needs of an organization in terms of technology and data to make solid business decisions.

After evaluating the three different maturity models, it was concluded that they can be a favourable tool to be used by healthcare organizations to add value to their business and augment the organization financial benefits.

This paper was focused on highlighting the importance of Business Intelligence maturity models in the healthcare domain providing a comprehensive review of existing healthcare maturity models and tries to identify the main features of the four presented models as well as the common success factors in adopting a Business Intelligence Maturity Model in Healthcare organizations.

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