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Creating a Maturity Model for Business Intelligence in Healthcare

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CREATING A MATURITY MODEL FOR BUSINESS INTELLIGENCE IN HEALTHCARE

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DISSERTATION APPROVAL FORM

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This dissertation is approved as a credible and independent investigation by a candidate for the Doctor of Science in Information Systems degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this dissertation does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department or university.

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ABSTRACT

Healthcare is a very complex, knowledge-driven industry. The accumulation of data is quickly outpacing the capacity to use the information to improve the efficiency and quality of healthcare. At the same time, the demand for higher level knowledge to manage consumer information and to predict outcomes of care continues to rise. Business intelligence (BI) can help organizations improve efficiency in managing information and can provide decision makers with timely and accurate information. The use of a business intelligence maturity model can provide organizations with a systematic method for assessing their maturity level relative to important process areas critical to the organization's success.

The purpose of this dissertation is to evaluate existing BI maturity models and expand the use of a maturity model to include processes within healthcare. The processes, dimensions, and functionality at each maturity level in the model are created to encompass the complex information management needs within healthcare. This is done through an iterative process of development. The BI maturity model is then evaluated by verifying that problem requirements are met and validating its usefulness within a healthcare organization.

An assessment tool for determining organizational maturity is created and administered to several key BI stakeholders within a healthcare system. The results of that assessment are then used to determine the BI maturity level of the organization. This validation process provides invaluable feedback not only to the maturity model creation; but also to the assessment and understanding of the maturity level within the organization. The creation of a maturity model specifically for healthcare as well as a useful maturity assessment tool can greatly assist healthcare organizations in determining their level of BI maturity.

The maturity level of business intelligence within an organization is extremely important in strategy development. There is no doubt that information technology can help drive some of the changes needed for healthcare reform. Using a maturity model to create a BI roadmap will help the organization better understand and control the overall management of information within the organization.

DECLARATION

I hereby certify that this dissertation constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions or writings of another.

I declare that the dissertation describes original work that has not previously been presented for the award of any other degree of any institution.

Signed,

Patti Brooks

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CHAPTER 1

INTRODUCTION

Healthcare is increasingly dependent upon health information technology (HIT). However, the accumulation of data created through various healthcare information systems has outpaced the capacity to use valuable information to improve operational efficiency, clinical quality, and financial effectiveness (Ferranti, Langman, Tanaka, & McCall, 2010; Mettler & Vimarlund, 2009). Healthcare executives and clinicians are faced with the challenge of sifting through massive amounts of information to answer complex questions. The data from healthcare information systems comes from many different sources and formats and at different points in time, all increasing the difficulty of evaluating that data (McKinney, Hess, & Whitecar, 2012). Because the healthcare industry is increasingly driven by a fundamental need to maximize the quality of care while minimizing costs (Sanders, 2002), it is essential that healthcare organizations effectively understand and manage information in order to make critical decisions.

Organizations can improve efficiency in managing information through the use of business intelligence (BI). Business intelligence can be thought of as "a broad category of technologies, applications, and processes for gathering, accessing, and analyzing data to help its users make better decisions." (Wixom & Watson, 2010). The primary objective of business intelligence is to improve the timeliness and quality of input available for the decision making process. This implies that actionable information needs to be delivered at the right time in the right location and in the right form (Negash, 2004).

With careful and attentive use of business intelligence, it is believed healthcare facilities can transform large amounts of data into information that can improve patient outcomes, increase safety, enhance operational efficiency, and support public health efforts (Ferranti et al., 2010). This transformation can be assisted by a BI program that can ensure reporting, monitoring, and measuring of quality, effectiveness, and value in patient care (Madsen, 2012). Thoughtful approaches, which will allow managers and providers to understand their organization's BI

readiness and to understand the critical steps for developing a mature BI process for their organization, are needed in order to develop an overall BI strategy.

One way organizations can assess their readiness for business intelligence is through the use of a maturity model. The importance of a sound maturity model lies in its ability to guide and provide systematic maturity and a readiness assessment for BI stakeholders to develop a BI strategy (Chuah & Wong, 2011). While some maturity models for BI have already been established, there are known shortcomings in many models including the lack of a theoretical foundation and well-established evaluation criteria (Lahrmann, Marx, Winter, & Wortmann, 2011; Raber, Winter, & Wortmann, 2012). In addition, healthcare has complex processes that may not be adequately assessed in a general domain BI maturity model.

Overview of the Problem

A systematic approach to assessing information needs relative to business strategy is very helpful in any organization. Work processes and information needs in healthcare are very complex, being driven by many internal and external stakeholders including clinicians, consumers, federal and private payers, regulatory agencies, other healthcare facilities, and public health agencies. A business intelligence maturity model can be used to systematically assess information needs and maturity for healthcare. However, the maturity model needs to include the complexities of the healthcare environment. A gap analysis of healthcare complexities and BI maturity models suggests current models do not address some of the specific complexities of the healthcare domain.

Purpose of the Research

The purpose of this research is to develop a business intelligence maturity model that can be used in the healthcare domain to systematically assess BI maturity. The integration of both administrative/financial and clinical information is a very important component in healthcare business intelligence and is unique to the healthcare industry. In addition, the increasing regulatory and reimbursement pressures that require external data exchanges with outside entities, governmental agencies, and other healthcare facilities is a challenge because of inconsistent progress toward interoperability standards and common data definitions. In summary, this research will:

- Explore the complexities of healthcare that make information needs challenging
- Review background information on existing maturity models
- Analyze the gaps in BI maturity models relative to healthcare complexities
- Determine a list of requirements for a healthcare BI maturity model
- Create a maturity model that meets the requirements for a healthcare BI maturity model
- Validate the model as a BI assessment in a healthcare setting

Organization of the Dissertation

The dissertation is organized in the following manner. Chapter 2 includes the literature review including background information about business intelligence and complexities within healthcare along with potential implications for BI solutions. The concept of using a maturity model to systematically evaluate an organization's business intelligence maturity level will be introduced. Chapter 3 discusses the design methodology of a healthcare BI maturity model creation following a design science approach. It provides detail about the methodology including problem identification and motivation, objectives, design and development, demonstration, evaluation, and communication. Chapter 4 provides more detail on the actual design methodology including the evaluation of problem requirements in a gap analysis of existing maturity models and the iterative process of maturity model development. Chapter 5 provides detail on the demonstration and evaluation process of the maturity model development. The results of the organizational BI maturity level assessment within a healthcare organization will be reviewed. Chapter 6 provides an assessment of the evaluation and demonstration results as well as limitations and recommendations for future research. It concludes with the proposed contributions to research.

CHAPTER 2

LITERATURE REVIEW

This chapter presents an understanding of the role of business intelligence and how an organized BI strategy can benefit an organization. Some of the major complexities within healthcare and the potential implications for business intelligence will be reviewed. The concept of maturity models as a mechanism to systematically evaluate BI readiness will also be discussed.

Definition of Business Intelligence (BI)

The term "business intelligence" has been around for about 50 years and has continually evolved because of changing business requirements, new technologies, and methods of analyzing information. As a result, there are many definitions of business intelligence coming from different points of view (McKinney et al., 2012). The primary objective of BI systems is to improve the timeliness and quality of input available for the decision making process. This implies that actionable information needs to be delivered at the right time in the right location and in the right form (Negash, 2004). Table 1 lists several definitions for BI found in the literature.

Table 1. Definitions of Business Intelligence

BI Definition	Authors
An integrated set of tools, technologies, and programmed products that are used to collect, integrate, analyze, and make data available.	(Reinschmidt & Francoise, 2000)
A broad range of analytical software and solutions for gathering, consolidating, analyzing, and providing access to information in a way that is supposed to allow enterprise users to make better business connections.	(Adelman, Moss, & Barbusinski, 2002)
An architecture and a collection of integrated operational as well as decision support applications and databases that provide the business community easy access to business data.	(Moss & Atre, 2003)
A set of concepts, methods, and processes that aim at not only improving business decisions but also supporting realization of an enterprise's strategy.	(Olszak & Ziemba, 2003)
An enterprise architecture for an integrated collection of operational as well as decision support applications and databases, which provides the business community easy access to their business data and allows them to make accurate business decisions.	(Gangadharan & Swami, 2004)
The process of turning data into information and knowledge.	(Golfarelli, Rizzi, & Cella, 2004)

A system that combines data gathering, data storage, and knowledge management with analytical tools to present complex internal and competitive information to planners and decision makers.	(Negash, 2004)
An umbrella term that includes architecture, tools, database, application, and methodologies.	(Raisinghani, 2004)
The accurate and timely critical data, information and knowledge that supports strategic and operational decision-making and risk assessment in uncertain and dynamic business environments. The source of the data, information and knowledge are both internally collected within the organization and externally supplied by partners, customers, or third parties as a result of their own choice.	(Chang, 2006)
Getting the right information to the right people at the right time.	(Miller, Bräutigam, & Gerlach, 2006)
A set of powerful tools and approaches to improve business executive decision making, business operations, and increasing the value of the enterprise.	(Zeng, Xu, Shi, Wang, & Wu, 2006)
Applications and technologies which are used to gather, provide access to, and analyze data and information about the organization, to help make better business decisions.	(Wu, Barash, & Bartolini, 2007)
The process of gathering enough of the right information in the right manner at the right time, and delivering the right results to the right people for decision making.	(Xu, Zeng, Shi, He, & Wang, 2007)
A process that analyzes the information which resides in the company in order to improve its decision making process and consequently create a competitive advantage for the company.	(Jourdan, Rainer, & Marshall, 2008)
The ability of an organization to plan, predict, solve problems, think abstractly, comprehend, enable effective actions, and help to establish and achieve business goals.	(Wells, 2008)
A set of mathematical models and analysis methodologies that exploits the available data to generate information and knowledge useful for complex decision making processes.	(Vercellis, 2009)
A broad category of technologies, applications, and processes for gathering, accessing, and analyzing data to help its users make better decisions.	(Wixom & Watson, 2010)
A discipline that combines services, applications, and technologies to gather, manage, and analyze data, transforming it into usable information to develop the insight and understanding needed to make informed decisions.	(Turban, Sharda, Aronson, & King, 2011)

It can be observed that over time, the definition for BI appears to have broadened to include not only technology, but also organizational and business processes. This is important, because BI is not only about technology, but also organizational decisions, analytics, information and knowledge management, decision flows and processes, and human interaction (Herschel, 2010). For the purpose of this research, one of the broader definitions will be used: "Business intelligence (BI) is a broad category of technologies, applications, and processes for gathering, accessing, and analyzing data to help its users make better decisions." (Wixom & Watson, 2010). This definition will be used because of the exploration of business intelligence maturity models, which typically

involves assessing a broad range of organizational processes that are important to understanding business intelligence maturity.

Purpose of Business Intelligence

Business intelligence has evolved as one of the most critical applications within organizations to provide useful insight, support decision making, and drive organizational performance (Bose, 2006; Massa & Testa, 2005). The primary purpose of BI is to support decision making (Massa & Testa, 2005). However, BI is broader than implementing a decision support solution. Three general reasons why an organization might undertake a BI initiative are to (1) gain insight, (2) to provide a single version of the truth, or (3) to enable transformation within an organization (Lonnqvist & Pirttimaki, 2006; Watson, 2006; Watson, Abraham, Chen, Preston, & Thomas, 2004).

Some organizations implement BI to gain better insight into their business processes, strategies, and operations (Lonnqvist & Pirttimaki, 2006). BI can assist in making sense of the transactional data and helping decision makers gain a better understanding of trends and dependencies that impact the business (Lonnqvist & Pirttimaki, 2006). Many organizations implement scorecards and dashboards as key components of BI initiatives. These tools help visually summarize large amounts of data into formats that are easy to analyze (Watson & Wixom, 2007).

BI can assist in achieving a single consistent view of business information (Watson et al., 2004). BI infrastructure is often fragmented with data in different business applications or departments. Organizations face challenges with information coming from multiple sources, such as spreadsheets, databases, legacy systems, enterprise applications, and web applications. This is especially challenging if an organization undergoes a merger or acquisition (Eckerson, 2003; On, 2006). There can be issues with data quality and lack of trust in the information if there is not a single consistent view of business information. For most organizations, the primary reason BI projects fail is because of poor data quality (On, 2006). Obtaining a single consistent version of the truth for enterprise information is helpful in achieving high quality data and better data analysis (Andriole, 2006; Eckerson, 2006).

BI can enable change within an organization (Watson, 2006; Watson & Volonino, 2002). This is accomplished by providing timely information to decision makers so more informed

decisions about the existing and future state of the organization can be made. BI initiatives change how people work and which processes they use. It is not surprising that BI is more likely to flourish in a company that has a culture of change and continuous improvement (Watson, 2008).

Range of Business Intelligence Capabilities

The range of BI capabilities defined as business intelligence is very broad including BI tools, standalone analytical applications, real-time BI applications, performance management applications, service-oriented architecture (SOA)-based BI, as well as many emerging trends including mobile analytics, in-memory analytics, and cloud-based BI (Muntean, Bologa, Bologa, & Florea, 2011). Figure 1 displays the broad spectrum of BI technologies. In Figure 1, BI tools include enterprise reporting tools, ad hoc query tools, statistical analysis tools, online analytical processing (OLAP) tools, data mining tools, text mining tools, dashboards, scorecards, and predictive analytics/advanced analytics. Standalone analytical applications may be used for a particular domain or business problem. Real-time BI includes BI that is embedded in operational applications or business process management. Performance management includes many different applications, such as those used for business process management, business rules management, business intelligence, and data warehousing. Service-oriented architecture-based BI includes more powerful products because the analysis of business processes and rules offers support for the business analysis. Some of the upcoming trends include mobile analytics, in-memory analytics, and BI embedded in collaboration and social software and cloud-based BI (Feiman & MacDonald, 2010; Muntean et al., 2011). It can be noted that the technologies become increasingly more complex as they move towards the top of Figure 1.

BI is continuing to evolve and develop. There is a demand for real-time BI, business performance management, and pervasive BI (Watson & Wixom, 2007). Enterprise information integration, enterprise application integration, and real-time data warehousing technologies make it possible to deliver data that is only a few minutes old (Watson & Wixom, 2007). This allows decision making and operational business process changes to happen much faster.

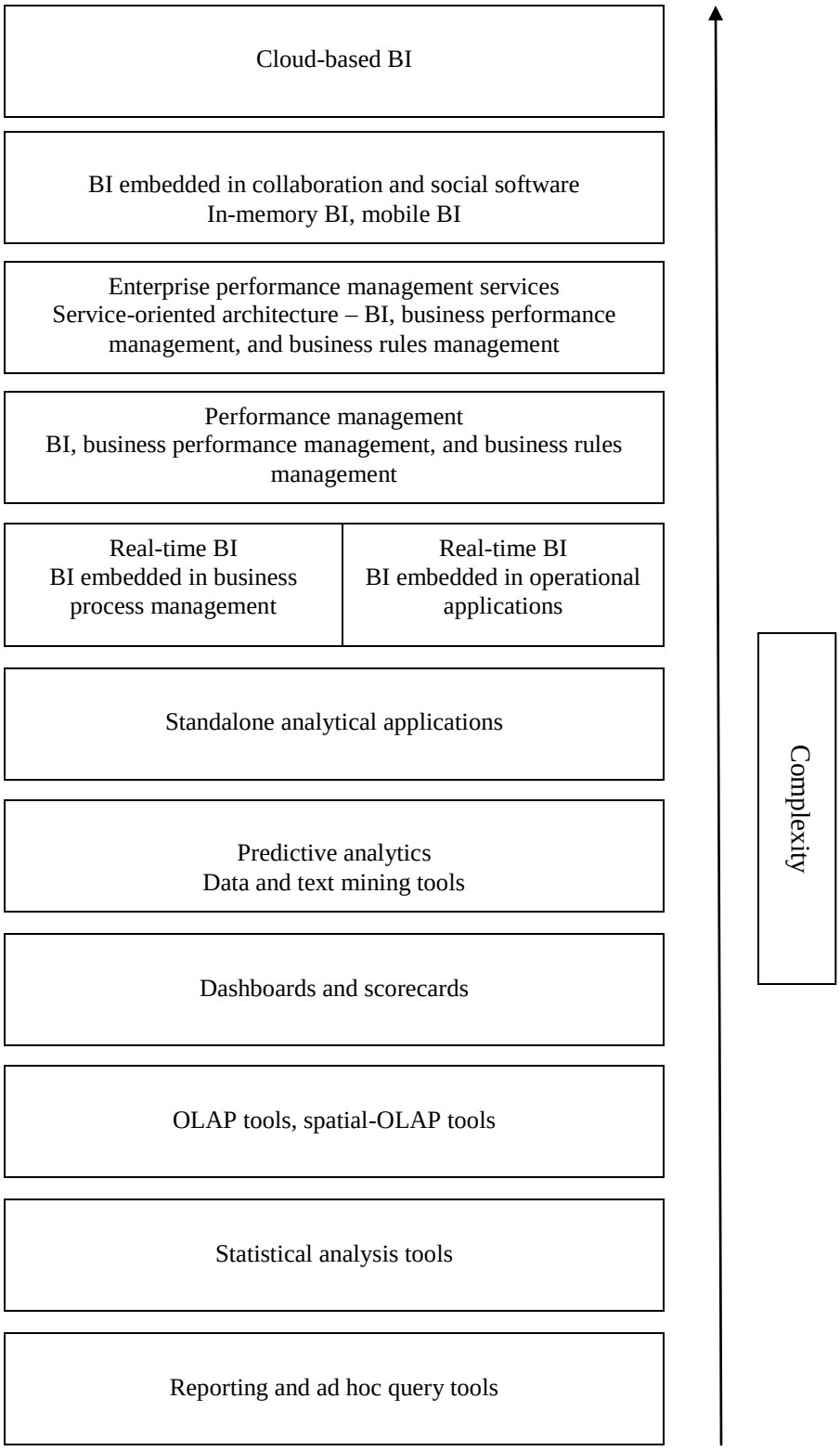


Figure 1. Spectrum of BI Technologies (Muntean et al., 2011)

Many companies have implemented scorecards and dashboards as key components of their business performance initiatives. These tools can provide a visual summary of large amounts of data related to the performance of the organization (Watson & Wixom, 2007). In the healthcare industry, many organizations have identified key performance indicators for both financial and clinical information.

As more organizations and users embrace BI, it is becoming more pervasive, providing users the information needed to perform their jobs more efficiently. Web-based systems provide access wherever there is an Internet connection. Event-based triggers can be used to initiate alerts. (Watson & Wixom, 2007). This can be very important in the healthcare industry where the timing of a patient intervention can be critical to the quality and outcome of care.

Figure 2 provides a visual summary of the architecture of a typical BI system including data sources, data storage, date use, and data views. The sources for data come from many different internal sources, such as departmental applications or enterprise applications as well as external sources such as the web or online databases. The data then goes through extraction, transforming, and loading (ETL) process into a data warehouse. From the warehouse, data can be pushed to various data marts which can use the data for reporting, online analytical processing, or data mining. The end user can then view the data in different formats such as dashboards or drill down reports.

Readiness and Critical Success Factors for Business Intelligence

As stated earlier, the scope of BI has changed over the years from a focus on technology to a broader perspective including organizational and business processes. The interconnectedness of markets and businesses represents a new challenge and forces organizations to operate in different ways (Gangadharan & Swami, 2004). Finding ways to bring together and make sense of the massive amounts of data within and across organizations is becoming a key business success factor (Gangadharan & Swami, 2004).

There are documented critical success factors for business intelligence. It would seem prudent to develop a list of factors and incorporate them into the readiness assessment process. Table 2 provides a list of the most commonly listed critical success factors for BI implementations or portions of products or processes that are used for BI implementations.

Figure 2. Scheme of Business Intelligence System (Olszak & Batko, 2012)

It can be noted from Table 2 below that there are common themes in critical success factors and strategies for BI success. This is especially true with strategic alignment and vision, management sponsorship and support, organizational culture/change management, people skills, resources, technology, and data quality. This lays the framework of areas to include in a BI readiness assessment.

Table 2. Critical Success Factors for BI Implementations

Critical Success Factors	**Authors**
BI governance	(Watson & Wixom, 2007)
BI portfolio management	(S. Williams, 2004)
Business champion	(Ariyachandra & Frolick, 2008; deHenry, 2007; Wixon & Watson, 2001; Yeoh, Koronios, & Gao, 2008)
Communication about the data and initiatives	(deHenry, 2007)
IT/business partnership	(deHenry, 2007; Eckerson, 2005; S. Williams, 2004)
Knowledge management	(Ocker & Mudambi, 2003)
Management sponsorship and support	(Ariyachandra & Frolick, 2008; deHenry, 2007; Eckerson, 2005; Ocker & Mudambi, 2003; Watson & Wixom, 2007; Wixon & Watson, 2001; Yeoh & Koronios, 2009; Yeoh et al., 2008)
Organizational culture/change management	(Ariyachandra & Frolick, 2008; Eckerson, 2005; Geiger, 2009; Ocker & Mudambi, 2003; Watson, 2008; Watson & Wixom, 2007; S. Williams, 2004; Yeoh & Koronios, 2009; Yeoh et al., 2008)
People skills (analytic, business, and IT)	(Ariyachandra & Frolick, 2008; deHenry, 2007; Eckerson, 2005; Geiger, 2009; Ocker & Mudambi, 2003; Watson & Wixom, 2007; Wixon & Watson, 2001; Yeoh & Koronios, 2009; Yeoh et al., 2008)
Project management	(Ocker & Mudambi, 2003; Yeoh et al., 2008)
Quality of data	(deHenry, 2007; Eckerson, 2005; Geiger, 2009; Yeoh & Koronios, 2009; Yeoh et al., 2008)
Resources	(Ariyachandra & Frolick, 2008; Eckerson, 2005; Watson & Wixom, 2007; Wixon & Watson, 2001)
Strategic alignment and vision	(Eckerson, 2005; Ocker & Mudambi, 2003; Watson, 2008; Watson & Wixom, 2007; S. Williams, 2004; Yeoh & Koronios, 2009; Yeoh et al., 2008)
Technology and data sources	(Eckerson, 2005; Geiger, 2009; Ocker & Mudambi, 2003; Watson, 2008; Watson & Wixom, 2007; Wixon & Watson, 2001; Yeoh & Koronios, 2009; Yeoh et al., 2008)

Business intelligence is essentially the essence of knowledge management; it is a strategy, not a purchased software product (McKinney et al., 2012). Knowing how to manage and leverage knowledge assets within the organization can significantly enhance the use of information and the results of BI initiatives (McKinney et al., 2012). In order to achieve success with BI strategy, it is important to understand how people think and work with one another. This can be done by performing a BI readiness assessment within the organization and incorporating an understanding of organizational processes in the readiness assessment tool.

A BI readiness assessment goes beyond a review of the technology infrastructure. It must also extend to an understanding of governance, policy, culture, and business processes. It is not uncommon for organizations to assume that all that is needed for a successful BI implementation is quick and accurate visually appealing reports. There are many other elements that must be taken into consideration in BI implementations, including business processes, organizational culture, people, resources, technology, and the organizational environment. These additional elements can actually make or break the BI implementation (McKinney et al., 2012).

Business Intelligence Maturity Models

One approach to assessing business intelligence readiness is through the use of a maturity model, and more specifically, a business intelligence maturity model. Maturity models (MMs) are a way to support effective management and continuous improvement for initiatives that are complex and have multiple components (Ahern, Clouse, & Turner, 2003; Crawford, 2006).

Table 3. Characteristics of Maturity Models (Lahrmann & Marx, 2010)

Characteristic	Description
Maturity concept	There are three different maturity concepts – people, process, and object (or technology). People (or workforce) capability defines "the level of knowledge, skills, and process abilities for performing an organization's business activities" (Curtis, Hefley, & Miller, 2010). Process maturity defines "the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective" (Paulk, Curtis, Chrissis, & Weber, 1993). Object (or technology) maturity defines the respective level of development of a design object (Gericke, Rohner, & Winter, 2006).
Dimension	Dimensions are specific capability areas, process areas, or design objects of the field of interest. They should be exhaustive and distinct (deBruin, Freeze, Kaulkarni, & Rosemann, 2005; Mettler & Rohner, 2009). Each dimension is further specified by measures (practices, objects, or activities) at each level of maturity (deBruin et al., 2005; Fraser, Moultrie, & Gregory, 2002).
Level	Levels are typical states of maturity of a certain dimension or domain. Each level has a distinguishing descriptor providing the level's intent and a detailed description (Lahrmann, Marx, Winter, & Wortmann, 2010).
Maturity principle	Maturity models scoring can be continuous or staged. Continuous maturity models allow a scoring of activities at different levels. Therefore, the level can be either the weighted sum of the individual scores or the individual levels in different dimensions. Staged models require the compliance with all elements of one level (Fraser et al., 2002). They specify a number of goals and practices to reach a predetermined level of maturity. Staged maturity models reduce the levels to the defined stages, whereas continuous maturity models open up the possibility of specifying situational levels (Lahrmann et al., 2010).
Assessment	The assessment approach can be either qualitative using descriptions or quantitative, such as a Likert scale (Fraser et al., 2002).

The term "maturity" assumes a "state of being complete, perfect, or ready" (Simpson & Weiner, 1989). To reach a desired state of maturity, there needs to be an evolutionary path of transforming from an initial to a target stage of progression (Fraser et al., 2002). It should be noted that maturity levels are not a goal, but rather a means to evaluate the adequacy of internal processes with respect to the objectives of the organization (Pederiva, 2003). Maturity models have a similar set of characteristics including the maturity concept, dimensions, levels, maturity principle, and assessment approach (Lahrmann & Marx, 2010). The characteristics of maturity models are described in Table 3.

Maturity Concept and Dimensions

Different exploratory research methods and combination of these methods have been used for designing and populating maturity models. Common methods include Delphi and case studies as well as focus groups (Becker, Knackstedt, & Pöppelbuβ, 2009; deBruin et al., 2005). The choice of the research method is influenced by the scope, stakeholders, and targeted audiences (Mettler & Rohner, 2009).

More than 100 maturity models have been published in the information systems field to date (Becker et al., 2009). Maturity models by themselves typically do not address organizational maturity with respect to how data is managed (Fisher, 2005). Business intelligence maturity models have been created to take into consideration the technology and data needs of an organization to make solid business decisions. In addition to technology, organizational processes and people skills are also very important concepts that need to be included for a comprehensive BI strategy. The dimensions can be taken from the common themes identified as critical success factors and strategies for BI success.

Maturity Model Leveling

The capability levels describe the level of functionality of the process areas and dimensions at each maturity level. Many of the business intelligence maturity models have their roots from the Capability Maturity Model (CMM) developed at Carnegie Melon University in 1986. CMM is a model used in software development to provide the guidelines to manage and control the software process in a software development project, and defines development maturity of organizations based on procedures and processes (Fisher, 2005; Paulk, Curtis, Chrissis, & Weber, 2006). While

the CMM model was developed as a process for software development, the concept and definitions can be easily used for the concept of business intelligence maturity as well. Business intelligence maturity models provide systematic maturity guidelines and readiness assessment for the use of technology and data to transform into usable information to develop insight and make informed decisions.

For purposes of this research, the Capability Maturity Model Integrated (CMMI) will be used as a template for defining the maturity levels. CMMI is actually the model that has replaced CMM. CMMI contains the essential elements of effective processes; therefore, the focus is on process improvement. Three critical dimensions of integration of CMMI include people, tools, and procedures and methods. It was chosen for this research because of its comprehensive nature and the fact that it is the basis of the majority of the maturity models evaluated. Figure 3 illustrates the five levels of CMMI along with their core characteristics.

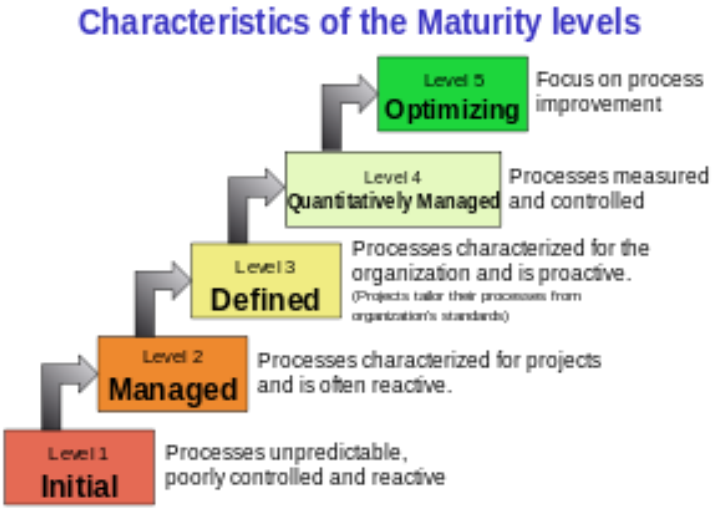


Figure 3. Characteristics of the CMMI Maturity Levels (CMMI Institute)

The five levels of CMMI are (1) Initial, (2) Managed, (3) Defined, (4) Quantitatively Managed, and (5) Optimizing. The process functionalities at each level progressively become more structured and focus on process improvement of overall organizational performance (Chrissis, Konrad, & Shrum, 2003; Wells, 2009). A broader definition of each maturity level is listed in Table 4.

Maturity Principle

CMMI actually supports two improvement paths, referred to as the maturity principle. One path enables organizations to incrementally improve processes for individual process areas or a group of related process areas. This representation is called a continuous approach. The continuous approach enables an organization to achieve "capability levels." The second path enables organizations to improve a set of related processes by incrementally addressing successive sets of processes. This is called the staged approach. The staged approach enables an organization to achieve "maturity levels." In either case, to reach a particular level, an organization must satisfy all the goals of the process area or set of process areas that are targeted for improvement (SEI, 2010).

Table 4. Definitions of CMMI Maturity Levels (CMMI Institute)

Level 1 – Initial	Processes are usually ad hoc and chaotic. Typically the organization does not provide a stable environment to support processes. Success often depends on the competence and heroics of the people within the organization and not on the use of proven processes. Services can work, but they often exceed the budget and schedule. At a Level 1 maturity, organizations tend to over commit, abandon their processes in a time of crisis, and are often unable to repeat their successes (SEI, 2010).
Level 2 – Managed	A managed process satisfies Level 1 and has the basic infrastructure needed to support the process. It has enterprise goals as well as process area goals. The processes are consciously planned and executed, employ skilled people, have adequate resources, and involve key stakeholders. A managed process is monitored, controlled, and reviewed. The process discipline in Level 2 assures that existing practices will be followed during times of stress (SEI, 2010).
Level 3 – Defined	A defined process satisfies Level 2 and has the necessary degree of rigor in standards, process descriptions, and procedures to be learnable, repeatable, easily audited, consistent in results and capable of producing identical results given identical circumstances. Processes are characterized for the organization and are proactive with an understanding of the relationships of process activities and detailed measures of the work, work products, and services. One of the key distinctions between Level 2 and Level 3 is the scope of the standards, process descriptions and procedures. At Level 2, the standards, process description, and procedures can be quite different for each instance of the process. At Level 3, these are more tailored from an organizational set of standard processes (SEI, 2010).
Level 4 – Quantitatively Managed	A quantitatively managed process satisfies Level 3 and is controlled using statistical and other quantitative techniques. Processes have measurable targets of quality and performance and they are used to manage the process. Quality and performance are measured and managed throughout the life of the process. Process performance is predictable. One of the primary differences between Level 3 and Level 4 is the predictability of process performance. Level 4 uses statistical and other quantitative techniques for these predictions (SEI, 2010)
Level 5 – Optimizing	An optimizing process meets all Level 4 criteria and is continuously improved through analyzing and understanding the causes of variation for the process. Processes focus on process improvement of overall organizational performance. A key distinction between Level 4 and Level 5 is the focus on managing and improving organizational performance. Level 4 tends to focus on understanding the performance at the subprocess level to make decisions about performance, while Level 5 uses data collected from multiple projects to make decisions about operational performance. These gaps are then used to drive process improvement within the organization (SEI, 2010)

Both methods are used in the industry. Unless an organization is planning to undergo CMMI certification, either approach is appropriate. The staged representation uses maturity levels to characterize the processes as a whole for an organization, while the continuous representation uses capability levels to characterize the state of the processes relative to each individual process area. Typically, in a staged approach, organizations focus on a manageable number of process areas at a time. The maturity levels are measured by achieving specific goals with each predefined set of process areas. Because this research uses maturity levels, the staged approach will be used. However, all the processes and their dimensions will be included in the maturity leveling.

Maturity models have been used for many different functions within different industries, such as project management, performance management, data warehousing, and information system maturity. The existing literature in BI has focused primarily on retail, manufacturing, finance, and government entities (Inmon, 2007; Mettler & Vimarlund, 2009). Generally the models are not directed toward any particular domain. An advantage of a generic BI maturity model is that is can be used for any domain. A disadvantage is that unique or highly important information needs of a specific domain, such as healthcare, may not be addressed in detail.

No evidence can be found in the literature for the creation or consistent usage of a BI maturity model specifically for healthcare. When evaluating BI in the context of healthcare, it is important to understand the complexities of healthcare and how BI needs and maturity may be impacted. Evaluating existing BI maturity models relative to the complexities in healthcare will help determine if an existing model can be used to adequately evaluate BI maturity in healthcare.

Healthcare Environment - Complexities and Implications for BI

It is claimed that healthcare is the most complex, knowledge-driven industry in the world and represents one of our most significant economic challenges (Glaser, 2012). The use of business intelligence in health care is increasingly important because of the need to improve effectiveness, efficiency, and quality of health services and to improve the availability of information in real time (Mettler & Vimarlund, 2009). Both healthcare data and business model challenges require the need for integration of clinical and financial data, the ability to handle diverse data formats for higher-level analytics, and the desire to deal with the demands and expectations of external data for clinical and financial decisions.

Complex Decision Making Processes

Processing of complex data is at the heart of decision making in healthcare (Kushniruk, 2001). Today's healthcare decision makers are facing growing demands for both clinical and administrative information (Mettler & Vimarlund, 2009). The interdisciplinary team of clinicians and technicians provides information that encompasses the medical record. In order to diagnose and treat a patient effectively, caregivers must, at a minimum, have access to the patient's medical record, rapidly changing evidence-based medicine, and provider orders guiding the process of patient care (Reid, Compton, Grossman, & Fanjiang, 2005). Figure 4 illustrates the components of a typical electronic health record (EHR) and demonstrates the overlap of clinical, administrative, and financial components of the record.

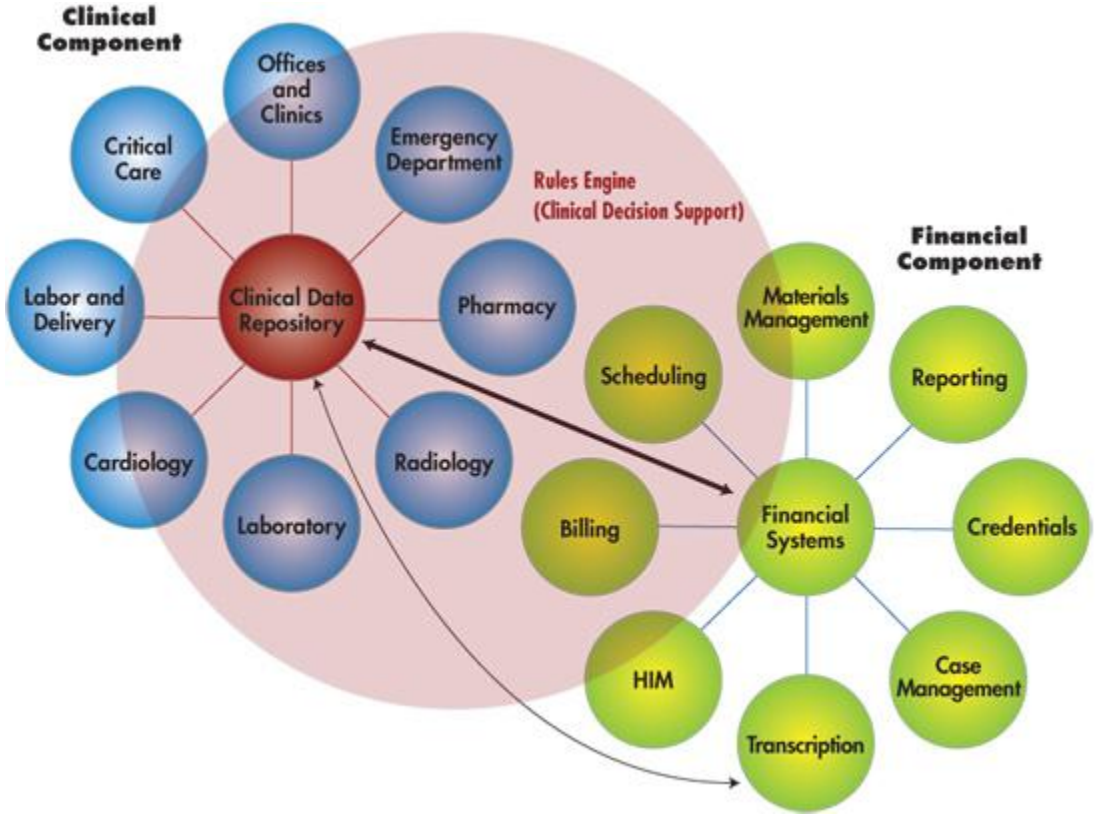


Figure 4. EHR Universe (McCoy, Bomentre, & Crous)

From the illustration, it can be noted that the clinical source systems are integrated or can be interfaced into a clinical data repository. This allows multiple applications or disparate systems to have one common view as the electronic health record. The advantage is allowing clinicians to view trends in the patient results and financial or quality analysts to view trends in patient care

(McCoy et al.). There are supporting sources of information from financial and administrative systems, such as registration, scheduling, billing, and prior diagnosis information that flow back and forth and interface with the clinical applications. Healthcare organizations need clinical, financial, and administrative information in order to measure, assess, control, and improve the quality and productivity of their operations (Reid et al., 2005). Even though various clinical and financial systems may share a common view, if the systems are interfaced rather than integrated, the silos of disparate systems very likely will not share consistent data definitions. This can result in confusion when analyzing data (Glaser & Stone, 2008).

A growing trend in healthcare that is not depicted in the EHR illustration is the demand for medical device integration with the EHR. Examples of patient information contained in medical devices include, but are not limited to, vital signs, telemetry and cardiac monitoring, electrocardiograms, smart infusion pumps, and electronic fetal monitoring systems. When the information is embedded in the EHR, the workflow for clinical staff is much more efficient because clinical decisions can be made when more information is available for decision making in one location.

Information from electronic health records often contains patient information recorded in many different structured formats, such as clinical, financial, and laboratory databases. Typical structured components include medical and nursing diagnoses; medication lists; medication administration records; allergies; demographics; clinical documentation in template format; vital signs; provider orders; and test results including lab, pathology, and radiology. (Wager, Lee, & Glaser, 2009). In addition, there are many unstructured formats in an electronic health record including free text reports, dictation, image data, wave forms, and genomics. (Ferranti et al., 2010; Inmon, 2007; Krishnan, Rao, Landi, & Sandilya, 2005). This makes it challenging to extract and analyze clinical information to use for healthcare management and clinical decision making. While it is not unique to the healthcare industry to have a mixture of structured and unstructured data, the fact that there are different formats of information to analyze for clinical decision making is challenging.

Reimbursement Model Complexities

Not only is healthcare decision making complex, the US healthcare business model is complex as well. The reimbursement system consists of a broad mix of payer sources, including

self-pay; commercial insurance; and federal government programs, including Medicare, Medicaid, the veteran programs, and Indian Health Services. There are also different reimbursement methods, such as fee-for-service, which means the patient is expected to pay for the provider of the healthcare after a service is rendered; prospective payment systems in which predetermined rates are determined and paid for each hospital discharge; and methods based on performance, such as value-based purchasing (LaTour & Eichenwald, 2010; Wager et al., 2009). The method used for reimbursement depends on factors such as where the service was provided (in a hospital or clinic), the designation of the facility (often based on size of the facility or distance from another facility), and the type of payer (such as commercial insurance versus Medicare).

Care Delivery Model Complexities

Healthcare systems are rapidly changing and being driven by a system of accountable care, with integration as one of the key components. The goal of integration within accountable care organizations (ACOs) is to ensure that the health and wellness of the population is managed, the most cost-effective care is provided, clinical processes are streamlined, necessary reporting is available, and payments and reimbursement are appropriate (Glaser, 2012). Because ACOs encompass many health care facilities, they create pressure to obtain, analyze, and use data from external sources across the continuum of care to make healthcare decisions (Spooner, 2012). In addition, there are integrative concepts, such as translational medicine, which include bridging primary research, clinical research, and bedside care, so decision support and predictive capabilities can be fully integrated and available for the care and treatment of patients (Nelson, 2010).

In healthcare, not only are there many internal customers to satisfy, but also external agencies and governmental authorities which tie reimbursement to quality and cost effectiveness of patient care. The demand for electronic information between different healthcare entities is growing rapidly now that many organizations have the core of their electronic health record systems in place. Exchanging data can be difficult because of inconsistent structure and format. In order to efficiently share and use data from multiple institutions, data must be built upon common words (data elements and terminology), structures, and organization. This requirement is a component of interoperability (Brooks, 2010). While there has been significant movement toward data standards for interoperability, there is a considerable amount of work yet to be done in order to freely exchange and interpret data from outside sources. The need to make electronic health records

interoperable is the essential component of a National Health Information Network (NHIN) (Hebda & Czar, 2013).

Movement Towards Patient-Centered Care and Consumer-Driven Healthcare

There is an ongoing movement toward patient-centered care where patients or consumers are more involved in their healthcare. Some of the underlying information technologies that support patient-centered care include electronic health records, personal health records, remote monitoring/telehealth, and self-service technology. Electronic health records provide the means to improve care processes and disease outcomes by making clinical information available to all clinicians taking care of a patient. Personal health records increase the engagement of patients into the health care process. As more of the electronic health record information is available to be integrated into the personal health record and vice versa, the depth of information available in making decisions will greatly increase. The use of remote monitoring to electronically transfer a patient's information, such as blood pressure or glucose readings, has increased over the last few years. This is especially important for the monitoring of chronic medical conditions.

Self-service technology includes ways of making care convenient and at the same time getting the patient more involved in their care. Examples of self-service technology in health care include kiosks for scheduling, registering, or triage assessment. The tools to support self-service continue to grow, including the use of the Internet, cell phones, digital telephony, kiosks, as well as software tools such as patient portals, social media, and portable device applications. The ability to import the external data from the patient in discrete data format can be a challenge and meets with mixed reactions by providers (Tang, Ash, Bates, Overhage, & Sands, 2006). Table 5 describes some of the key complexities which have been described in detail as well as implications for BI.

Healthcare is an industry that has been described as "Data Rich, but Information Poor" (DRIP) (Nelson, 2010). Part of the reason is the way the healthcare profession has evolved. Up until the last one or two decades, most healthcare organizations used computers for billing and scheduling, but did not necessarily have the applications to support patient care workflow and decisions. This is evolving in part because of the vision of healthcare by the Institute of Medicine: "The right care for every person every time" (Institute of Medicine, 2001). What this means is care that is safe, effective, efficient, patient-centered, timely, and equitable. Organizations that are

focusing on the effectiveness and efficiency of their organizations use data and analytics to support the technically advanced healthcare system (Nelson, 2010).

Table 5. Healthcare Complexities and BI Implications

Healthcare Complexities	Description	BI Implications
Complex decision making processes	Healthcare decision making is often complicated by the need to integrate ill-structured, uncertain, and potentially conflicting information from different sources (Kushniruk, 2001). Medicine is both an art and a science; not every patient will react the same way to a treatment. Decisions may depend on the function of the task and the expertise of the decision maker (Kushniruk, 2001).	• Both discrete and non-discrete data are components of the electronic health record, including documentation in discrete, free text, and imaging formats. • To achieve full benefits of BI, organizations need to integrate data that has historically been siloed in financial, operational, and clinical systems ("Business intelligence for healthcare: The new prescription for boosting cost management, productivity, and medical outcomes," 2009). • Whenever possible, evidence-based practice provides the means to provide consistent, quality care (Hebda & Czar, 2013). Current practice involves little time for evaluating research to make clinical decisions. Consequently, every attempt must be made to embed clinical decision support tools into the workflow of clinicians.
Reimbursement methodologies	Mixed payment mechanisms make healthcare reimbursement very complex.	• The mixture of payment mechanisms makes processing and analyzing of data complicated (LaTour & Eichenwald, 2010).
Delivery models to eliminate fragmentation of services	Different payment and delivery models are being developed in an effort to decrease overall healthcare costs. Accountable care organizations (ACOs) are one delivery model to control the total cost of care, quality, and effectiveness of services across the continuum of care including hospitals, clinics, nursing homes, home health agencies, and other entities. The concept behind an ACO is to shift the paradigm from payment per service rendered to a focus on wellness (Hebda & Czar, 2013).	• Changes in delivery and payment methods require the integration of information from multiple organizations to make decisions. • By combining information across the continuum of care, predictive analytics can be used for more concrete decisions about patient care. • Data standards have only been minimally required causing interoperability and integration issues.
Focus on patient-centered care and consumer-driven healthcare	There is an ongoing movement to involve patients in healthcare decisions. This includes sharing health information and providing tools, such as telehealth and personal health records (PHRs) to assist in communicating and managing care (Hebda & Czar, 2013).	• As PHRs mature, patients will be requesting their PHR information be shared with providers and integrated into electronic health records. • The movement to connect and provide care to patients in their homes will continue to rise.

There is a wealth of opportunity in healthcare to use BI tools and analytics to help drive efficiency. At the same time, there are many challenges because of the complexity of healthcare and how quickly reimbursement methodology, regulating agency policies, and technology are changing within healthcare. In the next section, we will review existing maturity models to understand if using an existing maturity model to assess a healthcare organization can capture the complexities known in the healthcare industry.

Analysis of Gaps in BI Maturity Models Relative to Healthcare Complexities

Six BI maturity models were analyzed to determine if the current processes used in the models could be used for healthcare and cover some of the primary healthcare complexities that have been described. Only the known models that specified a list of the processes and dimensions used in the model and that could be used without the assistance of a third-party vendor or consultant were considered for evaluation. The maturity model analysis included (1) the general purpose of the model, (2) a review of the processes and dimensions included in the model, and (3) an analysis to determine if processes related to integration of complex data and consideration of organizational and people process needs; integration of data from external sources; and interoperability capabilities to/from other settings responsible for business decisions is detailed in the model. A summary of the findings is provided in Table 6.

Table 6. Analysis of BI Maturity Model Gaps for Healthcare Domain

BI Maturity Model	Purpose	Integration of Complex Data and Consideration of Organization and People Processes	Integration of Data from External Sources	Interoperability Capabilities to/from Other Settings Responsible for Business Decisions
Business Information Maturity Model	Focuses on increasing the importance of BI (S. Williams & Williams, 2007). Key process areas include BI strategic position, partnership between business units and IT, BI portfolio management, information and analysis usage culture, process of improving business culture, process of establishing decision culture, and technical	Processes focus on organization and technology, but not necessarily integration of complex data.	Processes do not necessarily address external data.	Processes do not necessarily address interoperability.

	readiness for BI/data warehousing.			
CMM for BI	Focuses on people, processes, and technology using the capability maturity model (Raber et al., 2012). The dimensions include strategy, social system, technology system, quality, and use/impact.	Processes focus on organization, people, and technology, but not necessarily integration of complex data	Processes do not necessarily reflect addressing external data.	Processes do not necessarily reflect addressing interoperability.
Data Ware-housing Stages of Growth	Focuses on data warehousing and nine variables that define each stage (Watson, Ariyachandra, & Matyska, 2001). Process areas include data, architecture, stability of the production environment, warehouse staff, users, impact on users' skills/jobs, applications, costs, benefits, and organizational impacts.	Processes focus on the people and technology aspects of a data warehouse. In the highest level of maturity, integration of operational systems is mentioned.	Processes do not necessarily reflect addressing external data.	Processes do not necessarily reflect addressing interoperability.
Dataflux	Focuses on the Enterprise Data Management MM to help companies identify and quantify their data maturity and assess the risks of undervalued data management practices (Fisher, 2005). People, process, technology, and risk and reward are defined in the dimensions.	Processes focus on organization, people, and technology but not specifically complex data integration.	Processes do not necessarily reflect addressing external data.	Processes do not necessarily reflect addressing interoperability.
EBI2M	Focuses on both staged and continuous representation for enterprise business changes and data maturity. Factors for maturity include data warehousing, master data management, metadata management, analytical, infrastructure, performance management, and balanced scorecard (Chuah & Wong, 2012).	Processes focus on tools and technology at the enterprise level. Complex integration is not specifically mentioned. The model is fairly new and full detail could not be found at this time.	Processes do not necessarily reflect addressing external data.	Processes do not necessarily reflect addressing interoperability.
TDWI's BI Maturity Model	Focuses primarily on the technical aspects of maturity. The eight key process areas include scope, sponsorship, funding, value, architecture, data, development, and delivery (Eckerson, 2007b).	Processes focus on technical aspects of BI maturity, but not necessarily complex data integration.	Processes do not necessarily address external data	Processes do not necessarily address interoperability

Processes for people, strategy, and technology are all included in the Capability Maturity Model (CMM) for BI, since integration of these three areas is the primary focus of this model. The data needs including integration of complex or external data and interoperability of data are not specifically mentioned in the maturity level functionality suggested for each dimension (Raber et al., 2012).

The focus of the Data Warehousing Stages of Growth Maturity Model is on the maturity of the data warehouse itself, including three stages of evolution: initiation, growth, and maturity. There is a variable that addresses applications. The focus is on reports and queries, and in higher stages, data mining for predictive modeling and integration with operational systems. While integration is addressed, specific details about the integration and interoperability are not addressed in the summary of the model itself (Watson et al., 2001).

Three of the four dimensions in the Dataflux maturity model include people, process, and technology. The maturity concept is based on capabilities of an organization and the idea that organizations increasingly understand their data management problems and understand the importance of data to the success of the organization (Fisher, 2005). The reliability of this model is not documented (Lahrmann et al., 2010). It should also be noted that while Dataflux is considered a data governance maturity model, it is wrapped in with several other products as part of a vendor solution. Therefore, it may be questionable whether or not it should be included in this analysis, since products that required third party or consulting assistance were excluded from the analysis.

The Enterprise Business Intelligence Maturity Model (EBI2M) focuses on both staged and continuous representation for enterprise business changes as well as data maturity. This is a key difference with many other earlier maturity models, which primarily either focus on the technology or the business, but not necessarily both. The seven factors considered for key maturity include data warehousing, master data management, metadata management, analytical, infrastructure, performance management, and balanced scorecard (Chuah & Wong, 2012). The continuous representation of the maturity model suggests thirteen dimensions including change management, organization culture, strategic management, people, performance management, balanced scorecard, quality, data warehousing, master data management, metadata management, analytical, infrastructure, and knowledge management. This model is fairly new. Therefore, the method of analyzing an organization could not be found at this time.

The TDWI BI maturity model primarily focuses on the technical aspects of maturity. The eight key process areas include scope, sponsorship, funding, value, architecture, data, development, and delivery (Eckerson, 2007b). The concentration of the model began as an assessment for maturity of a data warehouse, but it has been adapted for use in business intelligence maturity as well. However, the questions in the assessment primarily cover technical aspects of data maturity; not to the level of asking about integration of complex data, external data, or interoperability.

In summary, the maturity model evaluation in Table 6 suggests potential issues for total BI coverage within healthcare. The processes/dimensions and known shortcomings in existing maturity models confirm this researcher's observation that it may be hard to operationalize the complex processes within healthcare through an existing maturity model. While other industries require integrated data and data from external sources, the depth of information needed for healthcare is very complex. Payment structures and delivery models are changing to incorporate responsibility for populations of consumers. The drive for patient safety, transparency in healthcare, error reduction, increased efficiency, and additional requirements from regulatory agencies continue to shape the delivery of healthcare. In addition, consumers are likely to assume greater responsibility for their healthcare and demand more and better exchange of information in the future (Hebda & Czar, 2013). All of these factors have implications for BI strategies and need to be taken into consideration in understanding the BI maturity of an organization.

By including integration and external data as separate dimensions, assessment questions can be used to ascertain an organization's readiness for the higher levels of BI required for true integration and interoperability in health care decisions. While the earlier issue of diverse data formats in healthcare is a challenge, one could argue that consideration for this functionality should be included in maturity leveling within the technical process. The next chapter covers the design methodology for a proposed BI maturity model for healthcare.

CHAPTER 3

DESIGN METHODOLOGY FOR A BI MATURITY MODEL FOR HEALTHCARE

This chapter presents the design methodology for creating and evaluating a BI maturity model for healthcare and briefly summarizes the development steps of the model. However, Chapter 4 provides more details of the actual design process.

Design Science Methodology for Maturity Model Development

The focus on developing a maturity model for BI in healthcare follows guidelines that have been defined for design science. Design science aims at improving problem-solving capabilities by creating innovative artifacts, such as constructs, models, methods, and instantiations (Hevner, March, Park, & Ram, 2004; March & Smith, 1995). In design science, artifacts are created to solve problems. A maturity model is an artifact which serves to solve the problems of determining the status quo of its capabilities and derives measures to improve upon (Becker et al., 2009). The design process follows a design science research methodology composed of (1) identifying the problem and motivation, (2) defining objectives of the solution, (3) designing and developing an artifact, (4) demonstrating by finding suitable content for using an artifact that can solve a problem, (5) evaluating how well the artifact works, and (6) communicating the results so knowledge can be expanded (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). Peffers, et al. (2007) states that although the process is structured in a sequential order, the researcher may not actually proceed in a sequential order from activities 1 through 6. Figure 5 summarizes how a maturity model development can fit into this methodology.

Problem Identification and Motivation

The initial step of identifying a problem requires much rigor to understand complexities in healthcare as well as to evaluate the existing maturity models to determine if there are gaps in representing the known complexities in healthcare. Once the problem and motivation have been

identified, the objectives of a solution can be developed in the form of problem requirements. The design and development process for the artifact (maturity model) can then begin. This requires more rigor in determining the core processes, dimensions, and levels for each dimension. The demonstration of the use of the model will be done first through an evaluation process of its soundness and validation through a pilot study of the use in a practical setting. The need to document the design process and communicate results for further development and usage cannot be overlooked.

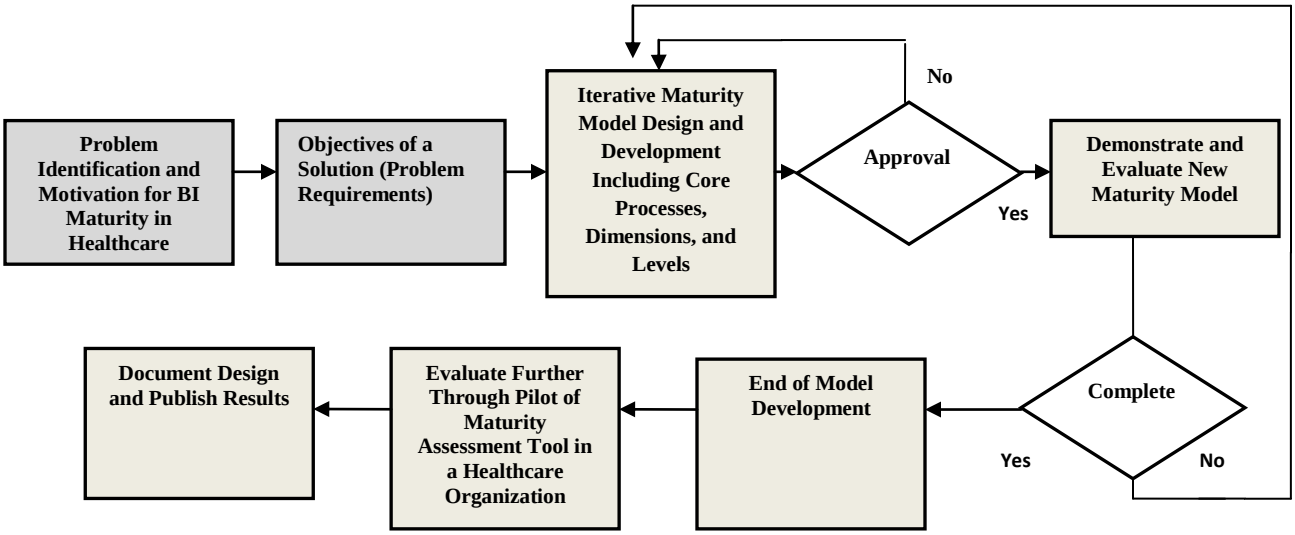


Figure 5. Design Steps for Maturity Model Development

The problem was identified after performing a literature review of the complexities in healthcare and completing a gap analysis of existing BI maturity models. A review of the process/dimension areas that are used in existing maturity models with some of the known healthcare complexities suggests that the use of a general domain maturity model may not fully cover some of the more complex processes that should be considered in healthcare BI maturity.

Objectives of a Solution (Problem Requirements)

The objectives, or problem requirements, were developed after performing a literature review of existing BI maturity models and critical success factors for BI implementations as well as developing a good understanding and review of complexities in healthcare that are critical considerations to evaluating BI maturity. The problem requirements were then reviewed by a group of five BI participants. The BI participants were chosen because of their strong industry

background in either healthcare or business intelligence and at least being somewhat familiar with a concept of maturity models. The participants were basically chosen based on the researcher's familiarity with participants in the industry who had the knowledge or interest and would be willing to commit the time required. The goal was to maintain five participants to assist in the model development. In this particular step, the BI participants were asked to verify that the problem requirements that were being suggested appeared to be appropriate. The problem requirement list was then compared with the six maturity models that were reviewed earlier to determine if the requirements had been identified in existing maturity models.

The details of the actual problem requirements are included in the next chapter. The review includes the results of the BI participant evaluation of the problem requirements. In addition, the six maturity models that have been included in the evaluation during this research were evaluated for inclusion of the problem requirements to verify that these have not been covered in totality in an earlier maturity model.

Iterative Maturity Model Design and Development

One of the key components of design science research is the iterative development of an artifact; in this case, a BI maturity model. A Delphi method was used with the same group of BI participants in the problem requirement review process. The iterative process consisted of not only agreeing on the overall process areas and dimensions, but also the functionality of each dimension at each of the five maturity levels. This required four iterations through the maturity model design and development process. Because the BI participants were located in different areas of the country, all work was done through e-mail and/or separate phone calls to each participant. When the BI participants were satisfied with the iterations as far as processes, dimensions, and maturity level functionality, the BI participants were asked to complete a summative evaluation by referencing the maturity model with the problem requirements to validate the requirements had been met.

Demonstrate and Evaluate New Maturity Model

In an effort to demonstrate the use of the BI maturity model within a healthcare organization, an organizational BI maturity model assessment tool was developed from the newly

created maturity model. The organizational BI maturity level assessment tool was in the form of a quantitative questionnaire that gathered perceptions of the maturity of each dimension and functionality at each maturity level of the dimension. It was developed by reviewing the expected functionality at each maturity level for each dimension. Five statements were developed encompassing the meaning of each level of functionality for each dimension from the maturity model that was developed.

Prior to the actual demonstration of the organizational BI maturity model assessment tool within a healthcare organization, the organizational BI maturity level assessment tool was evaluated for soundness. A two-stage sorting procedure was completed by a total of nine graduate students in an effort to strengthen the construct validity of the variables. They were asked to categorize the statement into similar categories. This was done in an effort to ensure the statements matched the actual dimensions that were being evaluated.

In addition to the sorting procedure, the group of five BI participants who assisted with the maturity model development was also asked to evaluate the organizational BI maturity level assessment tool in an effort to evaluate the appropriateness of the functionality described at each maturity level for each dimension as well as the wording of each statement in the assessment tool. The evaluation was quite favorable, with minor suggestions to wording of some of the statements within the assessment tool. The changes were made as suggested by the BI participants. Attention then turned to demonstrating the proposed maturity model through the actual use of the organizational BI maturity level assessment tool within a healthcare organization.

Pilot Evaluation Case Study in a Healthcare Organization

Fourteen healthcare facilities within the same healthcare organization were asked to participate in the case study. This included a combination of hospitals, nursing homes, clinics, and home health agencies. The quantitative organizational BI maturity level assessment tool was sent to 72 BI stakeholders. This group consisted of the top level administrative teams within each region, as well as leaders within IT, business/clinical intelligence, project management, and quality management. Both financial and clinical leaders were represented.

The organizational BI maturity level assessment tool consisted of 60 statements covering each key dimension and maturity level for each dimension. In addition to the 60 Likert scale statements, each dimension had a section where participants could add their own comments. The

comments could pertain to the perceived organizational maturity or to the quality of the statement for the pilot evaluation of the tool. In addition to the quantitative BI organizational maturity level assessment, an informal follow up qualitative interview was held individually with three of the key BI stakeholders who were also invited to be a part of the quantitative assessment. The purpose was to determine if their additional comments were congruent with the results in the quantitative organizational BI maturity level assessment tool.

Document Design and Publish Results

Design science is not complete without communicating the importance of the problem and artifact design to other researchers and relevant audiences (Peffers et al., 2007). In addition to publication of the dissertation, the concept of a BI maturity model specifically designed for healthcare has been presented and published at an international conference. The proposed dimensions and maturity levels were also presented at a state healthcare IT professional conference. The results of the healthcare organization quantitative assessment have also been shared within the organization that completed the assessment.

CHAPTER 4

MATURITY MODEL DEVELOPMENT

Chapter 4 provides the details of the actual design process of the healthcare BI maturity model. The first section will cover the detail of the objectives, or problem requirements, of the proposed research model. The manner in which the problem requirements were validated will be explained. The second section will discuss the iterative process of the maturity model development. The third section actually displays the finalized BI maturity model for healthcare that was created. The last section covers the method for evaluating the maturity model along with a detailed description of how an organizational BI maturity level assessment tool was developed and evaluated prior to its usage in a case study.

Problem Requirements of the Maturity Model

The problem requirements were developed following a thorough literature review. The literature review consisted of an understanding of the focus areas and shortcomings of existing BI maturity models, critical success factors for BI implementations, and the known complexities within healthcare information management. The problem requirements and sub-requirements are listed below.

Problem requirement #1: *Provide a conceptual structure for evaluating the use of business intelligence in healthcare.*

Sub-requirements for #1:

A. A maturity model should provide, for each healthcare process, different states of BI infrastructure and process development.

B. The different states of development should be conceptualized into levels and organized such that organizations can progress from one level to another.

C. Higher levels should be of greater utility than lower levels.

A maturity model for BI in healthcare should provide a framework that provides a consistent approach to the development of business intelligence in healthcare. Healthcare organizations can benefit greatly by being able to systematically evaluate their current level of maturity and their

desired level of maturity in an effort to develop a roadmap to a robust BI strategy plan. Maturity models define levels of important processes and dimensions to BI maturity. A BI maturity model can be an invaluable process because it outlines a path forward and helps organizations work toward a closer alignment of their business and IT processes (Hewlett-Packard, 2009). The functionality of the processes and dimensions being evaluated become increasingly more difficult to achieve as the maturity levels increase. The amount of change from one level to another is driven by the maturity level definitions and the corresponding dimensions.

Problem requirement #2: *Focus on the needs of operational, financial and clinical information.*

Sub-requirements for #2:

A. A healthcare BI maturity model should include process development that addresses the integration of operational, financial, and clinical processes.

B. Higher maturity leveling within integrated processes should include predictive analytics.

C. Expected levels of functionality for each dimension will be defined for each level of maturity.

In healthcare, both operational/financial and clinical reporting is needed. Healthcare processes typically cross departmental boundaries (Mettler & Vimarlund, 2009). Recent industry research has shown that healthcare organizations that focus on the integration of data are eliminating waste, improving profit margins and patient satisfaction, and providing better care ("Business intelligence for healthcare: The new prescription for boosting cost management, productivity, and medical outcomes," 2009).

Higher level functionality should include predictive data mining and predictive analytics at the point of care (Bellazzi & Zupan, 2008; Yoediono & Snyderman, 2008). Predictive analytics is the ability to perform data mining to uncover relationships and patterns with large volumes of data to predict behaviors and events. Predictive analytics uses past behavior to predict the future. (Eckerson, 2007a). There are great opportunities for improving patient care when electronic health records and other databases can be integrated and patterns and trends analyzed to determine a potential future outcome for a patient, especially if this information is available for the clinician at the time care is provided.

Problem requirement #3: *Focus on capturing key business intelligence processes and practices, taking into consideration specific processes within healthcare.*

Sub-requirements for #3:

A. A maturity model should capture key process areas and critical success factors in the development of business and clinical intelligence.

B. The key process areas in the healthcare model should take into consideration processes that bring additional complexity within healthcare. These include the integration of operational/financial and clinical information and the exchange and interoperability of external data.

C. Functionality at the appropriate maturity levels will include external benchmarking/interoperability and key performance indicators.

Maturity models should capture the key set of development processes and practices that are grounded in practice and academic literature (Paulk, Weber, Curtis, & Chrissis, 1995). Several critical success factors (CSF) were reviewed, with special attention to a CSF framework that has been developed for business intelligence (Yeoh & Koronios, 2010). The framework is divided into three main sections: organization, process, and technology. Important elements in the organization section include vision and business related factors and management championship and related factors. The process section includes team related factors, project management and methodology related factors, and change management related factors. The technology section includes data related factors and infrastructure related factors. Several other literature review sources were also used as references for critical success factors and further breakdown of the dimensions and expectations of functionality at each maturity level.

The complexities of healthcare were outlined in the literature review section. Healthcare organizations are continually trying to do more with less, operate more efficiently, and provide the best quality care by having information readily available to make better decisions. It is important that the healthcare complexities are understood and incorporated into a maturity model to truly evaluate an organization's maturity level.

Problem requirement #4: *Incorporate key processes that include people, technology, and organizational processes.*

Sub-requirements for #4:

A. In the healthcare BI maturity model, three broad process areas should include people, technology, and organizational processes.

B. Within these processes, further breakdown of dimensions will include key areas that are important to each process, including vision and BI strategy, knowledge management, staff skill levels, data quality, and technology infrastructure.

One of the shortcomings in BI maturity models is that many of them do not take into consideration the combined processes for technology, people, and organizational processes. BI is not just about technology. BI is not reporting, analytics, data warehousing, or dashboards – individually. But all of these things together are components of a BI program (Madsen, 2012). But even broader, BI is a strategic initiative in which organizations measure and drive the effectiveness of their competitive strategy (Gangadharan & Swami, 2004). When developing a BI initiative, one of the key questions to consider is whether or not the organization understands what BI is, what it takes to deliver the BI capabilities, and how BI can assist in leveraging the information assets and needs of the organization (Geiger, 2009). Some of the underlying considerations to evaluate include the culture of sharing and change within the organization, the technical infrastructure, the availability and quality of the data, the evaluation of business processes, and the degree to which the BI roles and responsibilities have been defined as well as the skill sets and experiences to fulfill those roles (Geiger, 2009).

Problem requirement #5: *Incorporate aspects of quality including system quality, information quality, and service quality.*

Sub-requirements for #5:

A. In the maturity model, the dimensions within the technology processes should address data quality.

B. Functionality that should be addressed in the maturity leveling includes data definitions/metadata, data standardization, and data governance.

Data quality is becoming increasingly important to many organizations. This is especially true in healthcare with extreme cost pressures and the desire to improve patient care (Leitheiser, 2001). Poor data quality can have substantial and economic impacts (Wang & Strong, 1996). Some of the impacts include customer dissatisfaction, increased operational cost, less effective decision making, and a reduction in the ability to make and executive business strategy (Redman, 1998).

In the healthcare industry, poor data quality can have far-reaching effects. Planning and delivery of services rely heavily on data from administrative, financial, and clinical sources (Kerr,

Norris, & Stockdale, 2007). For instance, evidence-based practice requires access to extensive research data, summarized and presented in a way that the clinician can use at the right time in the decision making process (Strauss, Richardson, Glasziou, & Haynes, 2005). In addition, quality data, especially related to timeliness and accuracy, is very important for administrative purposes such as the ability to quickly view a hospital bed roster and have quality information available for planning cost-effective services.

Problem requirement #6: *Provide an understanding of relationships between the different levels and key processes involved in a maturity model by incorporating theoretical underpinnings.*

Sub-requirement for #6:

A. The maturity processes should imply theory by demonstrating social and technical subsystems, and by incorporating key process areas and dimensions which include people, technology, and organizational processes.

As stated earlier, many maturity models lack a theoretical foundation, which can make it more difficult to understand the underlying maturity concept and relationships between the different parts of a maturity model (Raber et al., 2012). Five kernel theories were investigated to provide a theoretical background to the maturity model. The most prominent theory investigated and considered important for a BI maturity model was socio-technical theory. The argument in this theory is that social IS subsystems, comprised of people, methodological capabilities, and organizational practices, as well as the technical IS subsystems are interdependent and need to work with each other in order to maximize the benefits of a system (Bostrom & Heinen, 1977).

Other kernel theories that provide insight into a maturity model development include the cognitive fit theory, the task-technology fit theory, diffusion of innovation theory, and the IS success model. The cognitive fit theory proposes that the correspondence between the task and the format that information is presented leads to superior performance for individual users (Vessey, 1991). This can be an important consideration when the users are presented information. The task-technology fit (TTF) theory proposes that IT is more likely to have a positive impact on individual performance and be used if the capabilities of the IT system match the tasks that the user must perform. The factors that are evaluated include quality, locatability, authorization, compatibility, ease of use/training, timeliness, systems reliability, and the relationship with users (Goodhue, 1995; Goodhue & Thompson, 1995). The diffusion of innovation theory seeks to explain how, why, and at what rate new ideas and technology spread through culture. It looks at factors of innovation

being communicated over time through the social system. Different individuals have different willingness to adopt innovations (Rogers, 1962). One of the key components of the IS success model is that IS use primarily focuses on IS quality and IS use/impact (DeLone & McLean, 2003). If users do not trust the quality of the data, they may be less likely to use the data. The evaluation of a combination of theories provides a more solid foundation of the various processes, dimensions, and functionality at each maturity level that should be considered.

Validation of the Problem Requirements

In an effort to validate the problem requirements, the researcher involved a group of BI participants in the evaluation of the problem requirements. There were a total of seven participants included in the BI participant list. Two dropped out early in the research process, so two additional participants were added to maintain a total of five participants reviewing each step of the model iteration as well as the formative and summative evaluations. The criteria for choosing the participants was that they have a strong industry background in healthcare and/or business intelligence and were familiar with the at least the overall concept of maturity models. The demographics of the five active participants throughout the process are included in Table 7.

Table 7. Demographic Information of BI Participants

Primary Job Function	Number of Yrs in BI or Data Analytics	Number of Yrs in Healthcare Industry
Business intelligence or data analytics = 2 Healthcare consulting = 1 IT systems development = 1 Information architecture/business analytics = 1	0 – 5 years = 0 6 - 10 years = 2 11 – 15 years = 1 16 – 20 years = 2 > 20 years = 0	0 – 5 years = 1 6 – 10 years = 0 11 – 15 years = 0 16 – 20 years = 2 > 20 years = 2

A questionnaire including the list of problem requirements/sub-requirements was given to the BI participants as a method of formative evaluation of the appropriateness of the problem requirements. The actual questionnaire is included as Appendix A. Four of the five participants returned the survey. A summary of the results and comments are listed in Table 8.

Although the scores were primarily in agreement, there were two small changes made because of comments made. Requirement 1 was reworded to state “Provide a conceptual structure for evaluating the use of business intelligence in healthcare.” The suggestion was to change the word “use” to “manage.” However, after reviewing the statement, it was felt more appropriate to

change the phrase "managing the use" to "evaluating the use" since it more adequately reflects the purpose of a maturity model. There was one Sub-requirement added for Requirement #3 to include "Functionality at the appropriate maturity levels will include external benchmarking / interoperability and key performance indicators." After review of the comment for Requirement #5, it was felt data quality rules and master data management are implied in the second Sub-requirement, so no change was made. It is not surprising that Requirement #6 had a little lower score, since underlying theory is hard to notice. However, in the information explaining the problem requirements, several kernel theories that were taken into consideration as noted above.

Table 8. Results of BI/Domain Participant Problem Requirement Questionnaire

Requirement (Req) or Sub-Requirement (Sub)	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Median	Mean	Comments
Req #1	0	0	0	3	1	4	4.25	Would it be better to say you are managing the "effectiveness" of BI rather than the use of BI?
Sub #1	0	0	0	0	4	5	5	
Req #2	0	0	0	0	4	5	5	
Sub #2	0	0	0	0	4	5	5	
Req #3	0	0	0	0	4	5	5	1. Should include some mention of external benchmarking and/or continuous process improvement. 2. Should KPIs and metrics be mentioned here with the key process areas?
Sub #3	0	0	0	0	4	5	5	
Req #4	0	0	0	1	3	5	4.75	
Sub #4	0	0	0	0	4	5	5	
Req #5	0	0	0	0	4	5	5	
Sub #5	0	0	0	0	4	5	5	1. Consider adding "data quality rules" there or wherever most appropriate. 2. You might want to look at Master Data Management also.
Req #6	0	0	0	2	2	4.5	4.5	
Sub #6	0	0	1	2	1	4	4	

In addition to the BI participants validating the problem requirements, their validation and suggestions were used to evaluate existing maturity models. Because their familiarity with all six

models is somewhat limited and a comprehensive evaluation of all the models would involve a significant time investment, a slightly different approach was used to assist in the evaluation. The researcher used the responses and review of the problem requirements provided by the BI participants to evaluate for common components within each of the maturity models that were evaluated earlier. This evaluation adds verifiability and reproducibility to the research. It also strengthens the formative evaluation because it further validates the requirements for a BI maturity model for healthcare. A summary of the gap analysis is listed in Table 9 with each corresponding problem requirement.

Table 9. Gap Analysis of Problem Requirements with Existing Maturity Models

Problem #1: Provide a conceptual structure for evaluating the use of BI in healthcare. • A maturity model should provide, for each healthcare process, different states of BI infrastructure and process development. • The different states of development should be conceptualized into levels and organized such that organizations can progress from one level to another. • Higher levels should be of greater utility than lower levels...	
Business Information Maturity Model	This is a domain neutral BIMM. There are three levels of progressive maturity: Level 1 - Everyday use as before a data warehouse is introduced. Level 2 - The organization is beginning to understand the role of information for business needs. Level 3 – All parts of the organization are involved where information is used and decision processes are real-time (Rajteric, 2009).
CMM for BI	This is a domain neutral BIMM. Five levels of maturity: Level 1 – Initiate, Level 2 – Harmonize, Level 3 – Integrate, Level 4 – Optimize, and Level 5 – Perpetuate (Raber et al., 2012).
Data Warehousing Stages of Growth	This is a domain neutral BIMM. It focuses on data warehousing. Three levels of maturity: Initiation – The initial version of the warehouse. Growth – The expansion of the warehouse. Maturity – The warehouse becomes more fully integrated into the company's operations (Watson et al., 2001).
Dataflux	This is a domain neutral BIMM. It focuses on enterprise data management to help companies identify and quantify their data maturity and risks of undervalued data management practices. There are four levels: 1 – Undisciplined, 2 – Reactive, 3 – Proactive, and 4 – Governed (Fisher, 2005).
EBI2M	This is a rather new domain neutral BIMM. It focuses on enterprise business changes as well as data maturity. There are five levels of maturity: Stage 1 – Initial, Stage 2 – Managed, Stage 3 – Defined, Stage 4 – Quantitatively Managed, and Stage 5 – Optimizing (Chuah & Wong, 2012).
TDWI's BI Maturity Model	This is a domain neutral BIMM. It focuses primarily on the technical aspects of maturity, primarily the data warehouse. There are five levels of maturity: Infant, child, teenager, adult, and sage (Rajteric, 2009).
Problem #2: Focus on the needs of operational, financial, and clinical information. • A healthcare BI maturity model should include process development that addresses the integration of operational, financial, and clinical processes. • Higher maturity leveling within integrated processes should include predictive analytics.	
Business Information Maturity Model	This is a domain neutral BIMM. The levels primarily focus on the *who, what, when, where, why*, and *how* of information within the business. The term 'predictive analytics' was not found in the descriptions of the maturity levels (Rajteric, 2009)
CMM for BI	This is a domain neutral BIMM. The term 'proactive analytics' is referred to in one of the higher maturity levels (Raber et al., 2012).

Data Warehousing Stages of Growth	This is a domain neutral BIMM. Predictive modeling is addressed in the highest maturity level (Watson et al., 2001).
Dataflux	This is a domain neutral BIMM focusing on descriptions of data governance maturity (Fisher, 2005). The term 'predictive analytics' was not found in the descriptions of the maturity levels.
EBI2M	This is a domain neutral BIMM. The term 'predictive analytics' was not found. However, this model uses the CMMI maturity level definitions, which imply advanced analytic techniques at the higher level.
TDWI's BI Maturity Model	This is a domain neutral BIMM. Predictive analytics is referred to in the 'adult' maturity level (Rajteric, 2009).
Problem #3: Focus on capturing key business intelligence processes and practices, taking into consideration specific processes within healthcare. • A maturity model should capture key process areas and critical success factors in the development of business and clinical intelligence. • The key process areas in the healthcare model should take into consideration processes that bring additional complexity within healthcare. These include the integration of operational, financial, and clinical information and the exchange and interoperability of external data. • Functionality at the appropriate maturity levels will include external benchmarking and interoperability and key performance indicators.	
Business Information Maturity Model	Key process areas include BI strategic position, BI strategic leadership, partnership between business units and IT, BI portfolio management, information and analysis usage culture, process of improving BI culture, process of establishing decision culture, and technical readiness for BI/data warehousing (S. Williams & Williams, 2007). No specific mention of external data, interoperability, or complex data integration.
CMM for BI	Key dimensions include strategy, social system, technology system, quality, and use/impact. (Raber et al., 2012). No specific mention of external data, interoperability, or complex data integration.
Data Warehousing Stages of Growth	Key variables include data, architecture, stability of the production environment, warehouse staff users, impact on users' skills and jobs, applications, costs and benefits, and organizational impacts (Watson et al., 2001). No specific mention of external data or interoperability. The silos of information problem and single version of the truth are described in the maturity levels (Watson et al., 2001).
Dataflux	Key dimensions include people, process, technology, and risk and reward. Data integration with enterprise systems is mentioned in the highest maturity level within the model (Fisher, 2005).
EBI2M	Key dimensions include change management, organizational culture, strategic management, people, performance management, balanced scorecard, information quality, data warehousing, master data management, metadata management, analytical infrastructure management, and knowledge management (Chuah & Wong, 2012). No specific mention of external data or interoperability. A single version of the truth relative to data integration is a part of this model.
TDWI's BI Maturity Model	Key dimensions include scope, sponsorship, funding, value, architecture, data development, and delivery. No specific mention of external data, interoperability, or complex data integration (Eckerson, 2007b).
Problem #4: Incorporate key processes that include people, technology, and organizational processes. • In the healthcare BI maturity model, three broad process areas should include people, technology, and organizational processes. • Within these processes, further breakdown of dimensions will include key areas that are important to each process, including vision and BI strategy, knowledge management, staff skill levels, data quality, and technology infrastructure.	
Business Information Maturity Model	The three key success factors covered in the model include alignment and governance, leverage, and delivery. Seven key areas are evaluated including BI strategic position, partnership between business units and IT, portfolio management, information and analysis usage, process of improving business culture, process of establishing decision culture, and technical readiness of BI/DW (S. Williams & Williams, 2007). It an

	organization wants to leverage the full potential of BI, there needs to be a considerable amount of change within the business (N. Williams & Thomann, 2003). This model primarily assesses BI maturity based on the cultural perspective (Rajteric, 2009).
CMM for BI	Process areas cover people, technology, and organizational processes. Key dimensions include strategy, social system, technology system, quality, and use/impact (Raber et al., 2012).
Data Warehousing Stages of Growth	The primary process areas are in reference to the data warehouse. Key variables include data, architecture, stability of the production environment, warehouse staff users, impact on users' skills and jobs, applications, costs and benefits, and organizational impacts (Watson et al., 2001).
Dataflux	Focuses on helping companies identify and quantify their data maturity as well as assess the risks of undervalued data management practices. Key dimensions include people, process, technology, and risk and reward (Fisher, 2005).
EBI2M	Focuses on enterprise business changes as well as data maturity. Key dimensions include change management, organizational culture, strategic management, people, performance management, balanced scorecard, information quality, data warehousing, master data management, metadata management, analytical infrastructure management, and knowledge management (Chuah & Wong, 2012).
TDWI's BI Maturity Model	The model focuses primarily on the technical aspect of maturity assessment. Eight key areas are evaluated including scope, sponsorship, funding, value, architecture, data, development, and delivery (Eckerson, 2007b).
Problem #5: Incorporate aspects of quality including system quality, information quality, and service quality. • In the maturity model, the dimensions within the technology processes should address data quality. • Functionality that should be addressed in the maturity leveling includes data definitions, metadata, data standardization and data governance.	
Business Information Maturity Model	Information and analysis usage is one of the key dimensions (Chuah & Wong, 2011).
CMM for BI	Quality is included as one of the dimensions. Concepts within the dimensions include data quality management, standard definitions, consistency of data, and high availability of data (Raber et al., 2012).
Data Warehousing Stages of Growth	Data in general is one of the key areas within this maturity model focusing on data warehouse maturity. The model discusses data creation, maintenance (cleansing), use, and continuous refreshing of the data in the warehouse (Watson et al., 2001).
Dataflux	Data quality and master data management are addressed in the staging levels (Fisher, 2005).
EBI2M	Information quality, master data management, and metadata management are included as dimensions (Chuah & Wong, 2012)
TDWI's BI Maturity Model	Data in general is included as one of the technical areas (Chuah & Wong, 2011). Data trust and the assessment of data cleansing process are part of the assessment.
Problem #6: Provide an understanding of relationships between the different levels and key processes involved in a maturity model by incorporating theoretical underpinnings.	
Business Information Maturity Model	The model concentrates on three success factors, namely alignment and governance, leverage, and delivery (Chuah & Wong, 2011). However, no mention of an underlying theory could be found.
CMM for BI	The IS success model and socio-technical theory are both mentioned in an article describing the model (Raber et al., 2012).
Data Warehousing Stages of Growth	This model is derived from the stages of growth theory or model of development (Watson et al., 2001).
Dataflux	The data governance maturity model has a structured maturity model with defined maturity level functionality. However, no mention of an underlying theory could be found.
EBI2M	The EBI2M has a structured maturity model with five defined levels and different processes at each level using the CMMI approach to maturity leveling. However, no mention of an underlying theory could be found.
TDWI's BI Maturity	TWDI's BI maturity model is a structured maturity model focusing on the technical

Model	aspects of BI. It uses the BI Learning Cycle as one of its underlying assumptions (Eckerson, 2003).

It can be noted from Table 9 that none of the business intelligence maturity models evaluated meet all the problem requirements, primarily because they are domain neutral. All six models do have different levels of maturity that become progressively more difficult as the levels increase; therefore, problem requirement #1 is met in that regard. Problem requirement #2 refers to the focus on operational, financial, and clinical information. Because the models are all domain neutral, there is not a specific focus on the complex processes involved in healthcare. Problem requirement #3 refers to capturing key business intelligence processes, taking into consideration specific processes within healthcare, including integration of clinical and financial information and external data and interoperability issues. Because all the models are domain neutral, the healthcare complexities were not included. The Data Warehousing Stages of Growth and EBI2M refer to the need for integrated data when discussing silos of information and the need for a single version of the truth. For problem requirement #4, four of the six models incorporated processes addressing people, technology, and organizational processes. These include the Business Information Maturity Model, CMM for BI, Dataflux, and EBI2M. The two models that primarily had a technology focus (Data Warehousing Stages of Growth and the TDWI BI maturity model) primarily addressed the technology components. Problem requirement #5 refers to data quality. Data quality was addressed in some fashion in all six models. Problem requirement #6 refers to the need for an underlying theoretical underpinning. The models that appear to be explicitly theory-based are CMM for BI and Data Warehousing Stages of Growth. In addition, the TDWI maturity model uses the BI Learning Cycle as an underlying assumption. While this is not specifically a theory, it does provide a framework for working with the model.

In summary, the validation of the problems by the BI participants and the gap analysis of existing maturity models with the problem requirements assured that the problems were adequately represented and the model development could carry on. All of the existing models have some of the key components. However, the fact that they are domain neutral provides restrictions on assessment BI maturity in a complex healthcare environment. The next section discusses the iterative process of maturity model development.

Iterative Maturity Model Development

One of the key components of design science research is the iterative development of an artifact, in this case, a maturity model. A Delphi method was used with the same group of BI participants used in the problem requirement step of the design process. There were four rounds of review with the participants followed by an evaluation. The first round primarily focused on the high level process categories that should be included in the model. The second, third, and fourth iterations were semi-structured evaluations of the dimensions and leveling within each of the core processes. The fifth round was a review of the refined model followed by a verification questionnaire which served as the summative evaluation of the model.

Round One Study Results

In the first round, the participants were given the basic definition of a maturity model followed by a proposed grouping of high level core BI environment processes and corresponding sub-processes (dimensions) for the model. The processes were chosen by the researcher based on an extensive literature review of BI maturity models, critical success factors of BI, and healthcare complexities. The researchers were asked to give their opinion about the core processes as well as the dimensions listed under each of the core processes. Results of the round one study are listed in Appendix B. Initially, the researcher suggested three core processes: (1) organizational processes, (2) people and team processes, and (3) technology processes, with specific healthcare dimensions embedded in each of these processes.

The feedback from the BI participants suggested that the healthcare processes be considered as a separate core process and dimensions specific to healthcare be included in that new core process. In addition, there were suggestions about adding a few other dimensions. However, the suggested additions for dimensions were functionality descriptions at various levels of maturity that would be worked into the model.

Round Two Study Results

In the second round, the participants were given the first review of the proposed model with the processes, dimensions, and maturity attributes of each dimension at each of the five maturity levels. The suggestions from Round One were added to include a separate section for healthcare processes and a dimension (sub-process) for a learning organization. The maturity model that was

sent to the participants for round two is included as Appendix C. There were explanations included about each process to make sure all participants had the same basic level of understanding of why each process was included. The definitions at each level of maturity were listed. Participants were asked to review the model and make their suggested changes either to the process or dimension (sub-process) itself, or the defined level of maturity at each level within the dimensions.

The results of round two came back with suggestions for additions or changes to the maturity level functionality for various processes. There were no suggested changes to the core processes themselves. In addition, a suggestion was made to make the framework of the maturity model easier to read. The suggested changes were made by the researcher including a formatting change to make the maturity model easier to follow. Any changes from the Round Two review were highlighted so each reviewer knew what had been requested to be added by another reviewer. The suggested changes and new format were included for the third round of review.

Round Three Study Results

In the third round, the participants were given the proposed maturity model with the suggested changes as a result of the second round of review. The maturity model that was sent to the reviewers for Round Three is included as Appendix D. The changes suggested as a result of the third round of review were very minimal with only a few minor changes suggested.

Round Four Study Results

The minor changes suggested from Round Three were added to the model. At this point in the model development, the researcher took a close look at dividing the dimensions into similar categories as characteristics. The purpose of this breakdown was to establish variables that could be used for the development of a quantitative organizational BI maturity level assessment tool. In addition, some of the functionality within a few dimensions was moved to another dimension. In essence, the content itself was not changed, just further breakdowns of characteristics to begin the process of creating variables as well as moving a few of the functionality descriptions to dimensions that more closely matched their purpose. The maturity model that was sent to the reviewers for Round Four is included in Appendix E. The suggested changes as a result of the fourth round of review were almost non-existent.

Round Five (Final) Study Results: Proposed Maturity Model

From the previous round, some of the categories of characteristics were actually recombined in an effort to create a quantitative organizational BI maturity level assessment tool that could capture adequate maturity leveling for different dimensions, but be of reasonable length to expect participants to complete a quantitative assessment. The final maturity model with any new combined groupings of characteristics from Round Four was included for one last review. The final review was actually the suggested completed model. Table 10 provides a definition of the maturity levels as defined by CMMI leveling.

Table 10. Maturity Level Definitions of Processes to Develop and Operate a BI Environment

Level 1 – Initial	Processes are usually ad hoc and chaotic. Typically the organization does not provide a stable environment to support processes. Success often depends on the competence and heroics of the people within the organization and not on the use of proven processes. Services can work, but they often exceed the budget and schedule.
Level 2 – Managed	A managed process satisfies Level 1 and has the basic infrastructure needed to support the process. It has organizational goals as well as process area goals. The processes are consciously planned and executed, employ skilled people, have adequate resources, and involve key stakeholders. A managed process is monitored, controlled, and reviewed.
Level 3 – Defined	A defined process satisfies Level 2 and has the necessary degree of rigor in standards, process descriptions, and procedures to be learnable, repeatable, easily audited, consistent in results and capable of producing identical results given identical circumstances. Processes are characterized for the organization and are proactive with an understanding of the relationships of process activities and detailed measures of the work, work products, and services.
Level 4 – Quantitatively Managed	A quantitatively managed process satisfies Level 3 and is controlled using statistical and other quantitative techniques. Processes have measurable targets of quality and performance and they are used to manage the process. Quality and performance are measured and managed throughout the life of the process. Process performance is predictable.
Level 5 – Optimizing	An optimizing process meets all Level 4 criteria and is continuously improved through analyzing and understanding the causes of variation for the process. Processes focus on process improvement of overall organizational performance.

The finalized BI maturity model for healthcare that was developed as a result of the iterations of model development is shown in Figure 6.

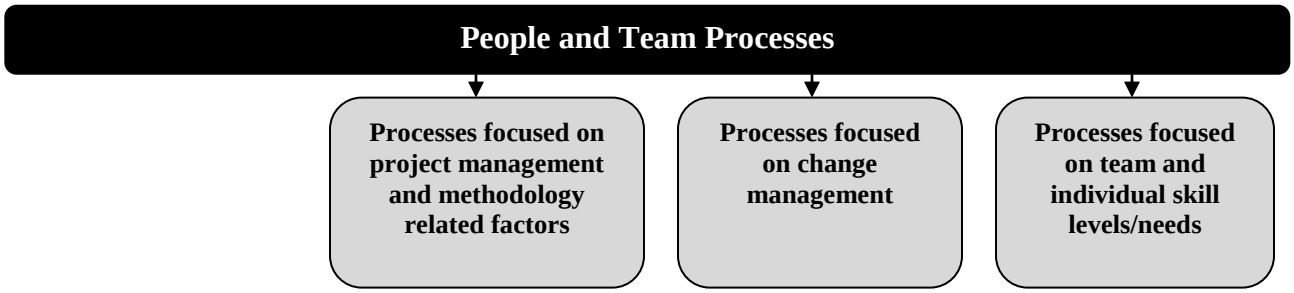
Organizational Processes

Processes focused on vision and strategy, sponsorship, and management engagement

Processes focused on creating a "learning organization" and transforming information in knowledge (intelligence)

	BI Vision and Strategy	**Management Engagement and Support**	**Learning Organization**
Level 1 - Initial	• BI initiatives and responsibilities are inconsistent or decentralized. • BI initiatives are not intentionally aligned with the vision and strategy of the organization.	• Management may have some interest in BI, but does not necessarily understand the resources needed for a strong BI process across the organization. • Sponsorship for BI initiatives is non-existent, inconsistent, or decentralized within the organization.	• There is some, but minimal, understanding of data and how the data can be used within the organization. • Communication of BI initiatives is haphazard and inconsistent.
Level 2 - Managed	• There may be some BI initiatives in place, but they are not consistently managed throughout the organization. • BI initiatives have not necessarily been communicated to each department.	• Management understands the resources needed for BI initiatives, including various costs, efforts related to time and materials, technology infrastructure, as well as both technical and clinical staff expertise, skills, and training. • BI sponsorship is typically managed by an area or business unit but may not necessarily be coordinated across the organization.	• There is a process in place to train staff about data and how to begin to use it as information. • There are goals for the sharing of information and knowledge gained from BI initiatives. • There is communication of the BI initiatives and it is aligned with organizational communication standards.
Level 3 - Defined	• There are defined standards for the development and operations of BI initiatives. • BI strategy, broken into	• Management provides the resources needed for BI initiatives, including cost, time, technology, and staff. • Management supports	• Executive leadership and a variety of staff are trained on how to access and use data and information. • The information gained

	tactical goals and projects, aligns directly to and is justified by organizational strategies.	the need for a data governance council to oversee the information management functions of BI. • There is a formal mentorship and training plan for the management team related to the BI program. • There is a standardized process to determine BI sponsorship across the organization.	from BI initiatives is managed and shared in a consistent, standard way. • Knowledge that is based on experience is documented. • There is a common standard for what information needs to be documented and communicated.
Level 4 – Quantitatively Managed	• BI initiatives include measured targets of performance relative to organizational vision and strategy. • BI initiatives are prioritized, in part, based on added value to the organization. This drives the needed supporting infrastructure, technology, and tools. • BI is an integral part of the approach for addressing strategic business decisions.	• Management is engaged in measurement, tracking, and reporting through the use of analytics across all areas of the organization. • Business sponsors use quantitative data to manage quality and performance on a regular basis.	• Information and knowledge gained through the evaluation of new patterns and relationships (data mining) is managed centrally, incorporated into metadata, and shared throughout the facility.
Level 5 - Optimizing	• There is a comprehensive BI strategy that is aligned with the organization's vision and strategy. • BI initiatives focus on continuous process improvement. • The BI strategy plan is updated on an ongoing basis, and is a dynamic and responsive part of the culture.	• Management is engaged in BI and clinical intelligence (CI) initiatives and they are consistently used for continuous process improvement for clinical and business processes throughout the organization. • BI goals are used to reward or incentivize BI leaders and various stakeholders. • Sponsorship is an integral part of BI project conception and prioritization. Senior leaders acknowledge and expect to be the sponsors of key strategic BI efforts.	• There is a culture of continuous learning with an evolution and maturation of ways BI and analytics can support and move the organization forward. • Knowledge discovery and utilization is dynamic and active across the organization. • New knowledge gained is part of process improvement activities across the organization and is used to make regular decisions throughout the organization.



	Project Management	Change Management	People and Team
Level 1 - Initial	• Project management standards have not been fully developed or are not necessarily tied to organizational goals. • Project management is not consistently applied throughout the organization.	• Change is resisted on a regular basis and can be avoided without consequence. • Change has the increased potential of producing unintended and/or detrimental consequences. • The change impact on budget, schedule, staffing, and other factors is often not estimated or not known. • When changes are implemented, there is not necessarily a strong connection between the change and the overall goals of the organization.	• Training and skill levels for BI are not known or do not necessarily align with the needs of the overall organization.
Level 2 - Managed	• Project management standards and expectations have been developed but they may not be followed on a consistent basis. • Key stakeholders are involved in the BI projects. • In general, there is an appropriate mix of skilled people (IT and business users) on project teams. • Projects are inventoried and tracked in silos, and some projects gain more exposure or	• Change management is often reactive. • There may be organizational standards for critical change management processes, but departments tend to migrate to and coordinate their own processes to support the standard. • Change management initiatives are overseen by executives but may not be closely monitored or controlled.	• Training, skill set, requirements, education, and application infrastructure for BI initiatives have been defined for both IT staff and business users but are primarily aligned with departmental goals. • There are skilled employees or outsourced services to manage, train, and be responsible for creating a learning environment.

	coordination based on their scope and leadership.		
Level 3 - Defined	• Project management standards, processes, and procedures are followed on a consistent basis. • Project management standards from external industry associations are generally used to design and manage projects as appropriate for their scope and impact. • All projects are tracked in a single place within the organization.	• Change is more often proactive than reactive within an organization. • There is regular and frequent communication to key stakeholders regarding change. • The quantity, quality, frequency, and impact of organizational change is estimated, managed, and controlled across the organization. • Change management initiatives are standardized and consistently managed across the organization.	• The training, skills, education, and applications for BI initiatives have been defined for both BI staff and business users and are aligned with organizational strategic goals. • Training and skill set coordination for BI is centralized and collectively managed for the organization.
Level 4 – Quantitatively Managed	• Project results are reliable and outcomes are generally predictable and as expected. • Project selection/approval methodology is based on quantitative measures rather than emotive arguments. • Projects are monitored using quantitative tools for processes such as time, cost, and scope. • Project status reporting is shared across the organization as appropriate. • Specific targets have been established for quality and performance.	• Systematic evaluation of proposed changes is undertaken. • Targets for quality and performance are established resulting in change initiatives that meet goals. • Metrics for change have been agreed upon by following standards established through data governance. The results of change are monitored with quantitative tools to determine the impact on the organization.	• Training and skill set requirements are monitored and evaluated for both IT staff and business users. • The business users and management staff are adequately trained to use quantitative tools for BI reports and dashboards. • Management drives the development for many of the reports and dashboards required for their department's initiatives.
Level 5 - Optimizing	• Projects are evaluated after completion by comparing initial estimations and goals against final results, including processes, planning, management, deliverables, reporting, and other collateral (i.e.,	• There is a culture of change and continuous improvement throughout the organization. • Change is embraced, organized, and easy to affect; it cannot be avoided or misaligned with organization goals	• There is a culture of continuous improvement with ongoing training and education related to BI analysis and use. • The organization proactively determines the appropriate skill levels needed for new BI

	lessons learned). • Projects are tracked at an organizational level and verified for alignment and congruency with organizational short term goals, and long term mission and vision.	without management's knowledge. • The culture of change is supported by management throughout the organization. • Change is managed at a tolerable pace and volume as appropriate for different areas of the organization and their resources (both technical and staff.)	initiatives, and re-evaluates needs for existing processes and initiatives. • The organization manages staff and training to achieve and maintain the ongoing skill levels.

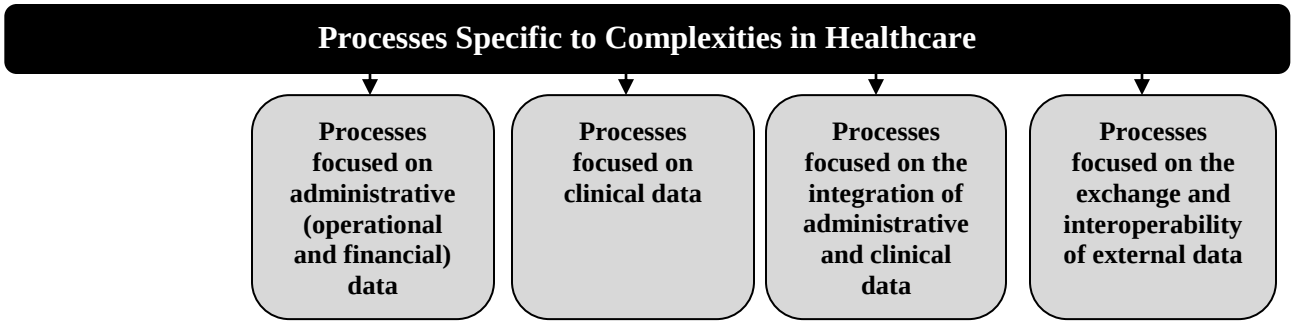
Technology Processes

	Processes focused on strategic technology infrastructure	**Processes focused on data quality**
	Data Architecture	**Data Quality**
Level 1 - Initial	• Data is retrieved out of individual departmental systems. • Data cleansing efforts are inconsistent. • Tools to retrieve and analyze data are ad hoc and inconsistent.	• The data and reports may or may not produce useful or consistent information. • Budgeting and work process changes are based on intuitive, subjective data. • Data collection and reporting is infrequent, inconsistent, or as requested. • Information is primarily obtained from static reports or non-electronic sources (i.e., paper charts, calendars, intake sheets) which are prone to transcription error when inputting paper-based data into electronic format. • Various reports showing similar or related data may be inconsistent. • The definitions and format of data are inconsistent across information systems and departments. • BI initiatives and responsibilities including infrastructure management, data validation, and data standardization are non-existent, inconsistent, or decentralized within the organization.

		• There is not a complete inventory of data or reporting.
Level 2 - Managed	• A data architecture strategy is in place to include growing needs and types of information in a healthcare environment. • There are organization-wide efforts to create data cleansing and extract, transform, and load (ETL) processes. • The infrastructure is in place to use tools to retrieve and analyze data and the tools to use have been planned from an organizational perspective. • The role of IT is operator of the infrastructure and provider of standardized IT related services.	• Static reports are the typical source for information. • Real-time reporting is used in some departments, but the overall use is minimal. • Skilled people have been put into place to manage the quality of the data. • There are some efforts to standardize data, but they are not consistent across the organization. • The organization has recognized the importance of standards. • The BI organization and responsibilities are managed and defined for specific projects, and may inconsistently focus on governance structure. • There is an inventory of reports and data sources that span across the organization. However, the metadata may be inconsistent or not readily available.
Level 3 - Defined	• Data cleansing and ETL processes are understood and standardized across the organization. • A BI strategy addresses the technical infrastructure requirements. • There are standards in the use of the tools to retrieve and analyze data. • The role of IT is a business partner working with business users.	• Data collection and reporting are scheduled and at regular intervals. • Data collection and reporting methods are standardized and are consistent. • There are standardized definitions for data that are used in BI initiatives across the organization. • Metadata is regularly referenced and seen as the key for defining data fields in all systems. • Metadata is managed as a corporate asset and responsibility. • There is an organizational standard for metadata that is published and referenced consistently. • There is a process in place where users who question the data within the reports can get consistent answers. • There is a data governance council in place consisting of members from IT and the

		business user community. The council focuses on BI and analytical programs, projects, practices, software, architecture, data validation, data standardization, data quality, data elements, data normalization, data origination, data stewardship, and data chain of control.
Level 4 – Quantitatively Managed	• There is a data warehouse in place which has "one source for the truth" (i.e., the data warehouse contains the standard master data on a patient across all information systems in the organization.) • Support tools are used for data cleansing and ETL processes. • The tools used assist with measuring targets for quality and performance.	• The ability to retrieve and use the data is flexible and available to the business users. • Performance tools are available and used by the front-end user for information needed for PI. • Predictive analytics, data mining, and data visualization tools (such as dashboards) are used on a regular basis. • Reporting is typically on a long term view (weekly, monthly, quarterly, or longer) although some reports may be on a short term view. • Measurable targets for quality and performance are in place using quality data. • Data collection and reporting have built in data quality thresholds for validation. • The data governance framework maintains business rules with automated processes. • Data governance is an organizational initiative and is appreciated by senior management because of the focus on standardization, consistency, and quality of data. • Data is collected and analyzed using standard, documented statistical and other quantitative techniques. • Reports demonstrate an organizational understanding of implementation of data governance, standard dictionaries, and data management.

Level 5 - Optimizing	• Information to make decisions is readily available and routinely used by the end users and key stakeholders because the data architecture and tools to retrieve data are in place. • There are mechanisms in place to optimize and streamline data cleansing and ETL processes.	• Quality data is used to analyze and understand the causes of variation in a process. • Strategic information is trustworthy and used for strategic decision making. • Dynamic and real-time data collection and reporting is available for all appropriate organizational metrics. • The organization has a coordinated and organized approach for dynamic reporting on all key organizational metrics; performance is in an on-demand manner that occurs with regular frequency with both a short term and long term view. • Standardized data is used on a regular basis for continuous process improvement at all levels of the organization.



	Healthcare – Administrative Data	**Healthcare – Clinical Data**	**Healthcare – Integrated Data**	**Healthcare – External Data**
Level 1 - Initial	• There is some, but minimal, integration of administrative data among departmental applications within the organization. • Administrative data across applications is inconsistent, causing redundancies in collecting data. • There is not a	• There is some, but minimal, integration of clinical data among the various clinical applications within the organization. • Clinical data across applications is inconsistent or non-existent, causing redundancies in collecting data.	• The value of embedding analytics into clinical and business processes is not necessarily considered when implementing or optimizing systems. • There is some, but minimal, integration of administrative and clinical information.	• There are inconsistent data definitions between internal and external data. • Interpretation and use of external data is difficult because of the lack of data standards.

	conscious rollout strategy to integrate administrative data across different departmental applications when purchasing IT systems.	• There is not a conscious rollout strategy to integrate clinical data across other clinical applications when purchasing information systems.	• There is not a conscious rollout strategy to integrate administrative and clinical information when purchasing information systems.	
Level 2 - Managed	• There are organizational goals to evaluate administrative systems, such as operational and financial systems, for the integration of applications. • There are adequate staffing levels in place to implement and support the administrative applications.	• There are organizational goals to evaluate clinical systems for the integration of applications. • There are adequate staffing levels in place to implement and support the clinical applications.	• There is a mechanism in place to evaluate and plan for the integration of core administrative and clinical data. • There are adequate staffing levels in place to interface and support the core administrative and clinical systems. • Skilled people are in place to interface the variety of types of information. • Administrative and clinical data is managed and coordinated by an organizational entity.	• There are some efforts in standard data definitions between internal and external data. • There is a process in place to monitor, control, and review the internal versus external data. • The organization is reviewing options for participation in regional data exchanges.
Level 3 - Defined	• There are defined data definition standards to allow for easy integration of administrative applications across various systems. • There are identified key performance indicators (KPIs) for operational and administrative data, but they are not well measured or used. • There is	• There are defined data definition standards to allow for easy integration of clinical applications across various clinical systems. • There are identified KPIs for clinical data, but they are not well measured or used. • New clinical applications and systems always have data standards and	• There are defined data definition standards (metadata) to allow for easy integration of administrative and clinical systems. • New applications and systems always have data standards and integration addressed as part of the implementation, education, and rollout process.	• Standard data definitions (metadata) are defined and used on a regular basis for both internal and external data. • The regular use of industry standards for nomenclature and classification systems is used. • The organization engages in the support of the development and management of local and regional data exchanges.

	standardization of the "sources" of administrative data. • Administrative systems conform and communicate effectively. • Consistent results are obtained because of integration of administrative systems.	integration addressed as part of the implementation, education, and rollout process. • Consistent results are obtained because of the integration of clinical systems. • The organization pursues evidence-based medicine tools to support clinical decision making.		
Level 4 – Quantitatively Managed	• Performance improvement activities are used on a regular basis and include KPIs consisting of critical administrative data. • Administrative information is used for predictive analytics**.**	• Performance improvement activities are used on a regular basis and KPIs consisting of critical clinical data. • Clinical information is used for predictive analytics. • Patient care staff dashboards are in use to identify targets of opportunities for clinical improvement initiatives. • Patient care staff decision support is used to help with complex treatment decisions. • The organization implements evidence-based medicine tools.	• Performance improvement activities include integrated information from administrative and clinical data. • Integrated administrative and clinical information is used for predictive analytics.	• Statistical and quantitative tools are used to manage internal and external data for performance improvement activities. • Predictive modeling includes both internal and external data. • The organization participates in external benchmarking for key processes.
Level 5 - Optimizing	• Process improvement activities are driven by administrative data. • Administrative data is continuously used	• On a regular basis, clinical information is available at the point of care, often evidence-based, in support of making clinical decisions. • Process	• Process improvement activities include administrative and clinical information used together to make decisions. • On a regular basis,	• External data is fully integrated into internal data systems (i.e., through the use of a regional data exchange.) • External data is used on a regular

	to manage and improve the organization, and to track both past and future performance in a dynamic way.	improvement activities include clinical information to make decisions on a regular basis.	information to make decisions (clinical with integrated administrative integration) is available at the point of care, often evidence-based. • The variances between data sources and systems and types of data are isolated due to management and coordination of data.	basis for continuous quality and process improvement of internal processes across the organization. • The organization actively coordinates external benchmarking with industry peers.

Figure 6. Finalized BI Maturity Model for Healthcare

Evaluation of the Proposed Maturity Model

Once the final proposed maturity model was complete, the BI participants were asked to complete an evaluation to verify that the maturity model met the initial problem requirements that were determined at the beginning of the design process. The questionnaire included the initial list of problem requirements. They were asked to give their perspective if the model actually covered the problem requirements that were initially developed. The actual questionnaire (summative evaluation) is included as Appendix F. All five participants returned the evaluation. The summary of the results and comments are listed in Table 11.

The results of the evaluation showed that the BI participants had a positive attitude about the problem requirements being met by the proposed maturity model. Therefore, based on the results of the summative evaluation, the next step was to demonstrate the viability of the proposed model using a case study.

Table 11. Results of BI/Domain Participant Maturity Evaluation

Requirement (Req)	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Median	Mean	Comments
Req #1				1	4	5	4.8	
Req #2				1	4	4	4.8	Be careful with the word operational. You should be OK if you are referring to operational reporting and not operational systems that run transactions.
Req #3				1	4	5	4.8	
Req #4				1	4	5	4.8	I believe physician buy-in is critical to the success of any initiative in a healthcare organization, especially if the initiative is perceived as being "sponsored" or "advocated" by Administration…that you have built change management into the model is critical!
Req #5					5	5	5	
Req #6					5	5	5	

Case Study for Determining Organizational BI Maturity Level

The demonstration portion of the design was evaluating the usefulness of the maturity model. This is sometimes referred to as the validation of the model (Conwell, Enright, & Stutzman, 2000). One approach to demonstrating usefulness is to implement the model in a real-life setting to determine if the model demonstrates the projected results. In an effort to reach several of the BI stakeholders in an organization in a short amount of time, the researcher chose to develop a quantitative organizational BI maturity level assessment tool. This was created by developing statements of maturity level functionality for each dimension from the newly created maturity model. The statements were written with the intent of being answered in a Likert scale format based on the perception of the BI stakeholder completing the quantitative assessment. The results would then be used to determine a BI maturity level score for the organization. The validity process used in developing the organizational BI maturity level assessment tool will be discussed in this chapter with the actual results of the case study discussed in the next chapter.

Organizational BI Maturity Level Assessment Tool

One set of statements for each of the thirteen dimensions was developed. The set of statements for each dimension included one for each functionality level of maturity. In other words, for each dimension, such as BI vision and strategy, there was a statement of what would be expected for functionality for Level 1, Level 2, Level 3, Level 4, and Level 5 maturity. The intent was that the participant would answer the statements based on a Likert scale of perception of BI maturity level within the organization. There were a total of 65 statements when the process began. Each of the statements was broken into a construct or variable.

In order to strengthen construct validity as much as possible, the literature was reviewed to use questions/statements or constructs/variables that had used in the past. A list of sources for statements, or adaptations of such, is provided in Table 12.

Table 12. Construct/Variable Sources

Construct/Variable	Survey Item	Code	Source
BI Vision and Strategy	Item 1	OVS1	(Raber et al., 2012)
	Item 2	OVS2	(Raber et al., 2012)
	Item 3	OVS3	(Raber et al., 2012)
	Item 4	OVS4	(Raber et al., 2012)
	Item 5	OVS5	(Raber et al., 2012)
Management Engagement and Support	Item 6	OMS1	Self-developed
	Item 7	OMS2	(Sulayman & Mendes, 2010);(Tan, Sim, & Yeoh, 2011)
	Item 8	OMS3	(Sulayman & Mendes, 2010; Tan et al., 2011)
	Item 9	OMS4	(Sulayman & Mendes, 2010);(Tan et al., 2011)
	Item 10	OMS5	(Tan et al., 2011) and self-developed
Learning Organization	Item 11	OLO1	(Iftikhar, Eriksson, & Dickson, 2003)
	Item 12	OLO2	(Iftikhar et al., 2003) and self-developed
	Item 13	OLO3	(Holt, 2002; Holt, Bartczak, Clark, & Trent, 2007)
	Item 14	OLO4	(Sulayman & Mendes, 2010) and self-developed
	Item 15	OLO5	(Iftikhar et al., 2003; Kulkarni & St. Louis, 2003; Sulayman & Mendes, 2010)
Project Management	Item 16	PPM1	(Schmietendorf, Scholz, & Rautenstrauch, 2000)
	Item 17	PPM2	(McBride, Henderson-Sellers, & Zowghi, 2004)
	Item 18	PPM3	(McBride et al., 2004)
	Item 19	PPM4	(Fauzi & Ramli, 2007; Garcia, Pacheco, & Andrade, 2010; Schmietendorf et al., 2000)
	Item 20	PPM5	(Fauzi & Ramli, 2007; Kulkarni & St. Louis, 2003; McBride et al., 2004)
Change Management	Item 21	PCM1	(Holt et al., 2007)
	Item 22	PCM2	(Holt et al., 2007)
	Item 23	PCM3	(Holt et al., 2007; Iftikhar et al., 2003)
	Item 24	PCM4	(Fauzi & Ramli, 2007; Holt et al., 2007)
	Item 25	PCM5	(Fauzi & Ramli, 2007; Holt et al., 2007; Iftikhar et al., 2003; Schmietendorf et al., 2000)

People and Team Skills	Item 26	PPT1	(Lahrmann et al., 2011; Raber et al., 2012)
	Item 27	PPT2	(Lahrmann et al., 2011; Raber et al., 2012; Sulayman & Mendes, 2010)
	Item 28	PPT3	(Lahrmann et al., 2011; Raber et al., 2012; Sulayman & Mendes, 2010)
	Item 29	PPT4	(Lahrmann et al., 2011; Raber et al., 2012)
	Item 30	PPT5	(Lahrmann et al., 2011; Raber et al., 2012)
Data Architecture	Item 31	TDA1	(Lahrmann et al., 2011; Raber et al., 2012; Schmietendorf et al., 2000)
	Item 32	TDA2	(Lahrmann et al., 2011; Raber et al., 2012; Schmietendorf et al., 2000)
	Item 33	TDA3	(Lahrmann et al., 2011; Raber et al., 2012; Schmietendorf et al., 2000)
	Item 34	TDA4	(Lahrmann et al., 2011; Raber et al., 2012; Schmietendorf et al., 2000; Tan et al., 2011)
	Item 35	TDA5	(Lahrmann et al., 2011; Raber et al., 2012; Schmietendorf et al., 2000)
Data Quality	Item 36	TDQ1	(Batini, Cappiello, Francalanci, & Maurino, 2009; Tan et al., 2011; Wang & Strong, 1996)
	Item 37	TDQ2	(Batini et al., 2009; Holt et al., 2007; Sulayman & Mendes, 2010; Tan et al., 2011; Wang & Strong, 1996)
	Item 38	TDQ3	(Batini et al., 2009; Sulayman & Mendes, 2010; Tan et al., 2011; Wang & Strong, 1996)
	Item 39	TDQ4	(Batini et al., 2009; Tan et al., 2011; Wang & Strong, 1996)
	Item 40	TDQ5	(Batini et al., 2009; Tan et al., 2011; Wang & Strong, 1996)
Data Standardization and Governance	Item 41	TSG1	(Raber et al., 2012; Tan et al., 2011)
	Item 42	TSG2	(Raber et al., 2012; Tan et al., 2011)
	Item 43	TSG3	(Raber et al., 2012; Tan et al., 2011)
	Item 44	TSG4	(Raber et al., 2012; Tan et al., 2011)
	Item 45	TSG5	(Raber et al., 2012; Tan et al., 2011)
Healthcare – Administrative Data	Item 46	HCA1	Self-developed
	Item 47	HCA2	Self-developed
	Item 48	HCA3	(Raber et al., 2012) and self-developed
	Item 49	HCA4	Self-developed
	Item 50	HCA5	Self-developed
Healthcare – Clinical Data	Item 51	HCC1	Self-developed
	Item 52	HCC2	Self-developed
	Item 53	HCC3	(Raber et al., 2012) and self-developed
	Item 54	HCC4	Self-developed
	Item 55	HCC5	Self-developed
Healthcare – Integrated Data	Item 56	HCI1	Self-developed
	Item 57	HCI2	Self-developed
	Item 58	HCI3	Self-developed
	Item 59	HCI4	Self-developed
	Item 60	HCI5	Self-developed
Healthcare – External Data	Item 61	HCE1	Self-developed
	Item 62	HCE2	Self-developed
	Item 63	HCE3	Self-developed
	Item 64	HCE4	Self-developed
	Item 65	HCD5	Self-developed

Other measures were taken to assure construct and content validity. The BI participants were given a copy of the first draft of the organizational BI maturity level assessment tool and asked to provide ratings on two components: (1) that the assessment statements adequately reflected functionality at each maturity level for each process and (2) that the proposed assessment statements were presented in a manner the user would be able to understand. The full questionnaire for the BI participants is included as Appendix G. The results and comments of the BI participant review are listed in Table 13.

Table 13. Results of BI Participant Organizational BI Maturity Level Assessment Review

Statement	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Median	Mean	Comments
OVS adequately reflected				4	1	4	4.2	Would not hurt to have a reference tool for those completing the survey with acronyms and terms used in BI and IT defined.
OVS understandable		1		1	3	5	4.2	1. Participant didn't feel rating scale was clearly labeled, so scored a "disagree" on all statements regarding being understandable. Therefore, this comment applies to all the "disagree" comments below. 2. I might add a little more detail on statement #4 – BI initiatives include performance targets linked to organizational strategy and are prioritized, in part, based on added value to the organization.
OMS adequately reflected				4	1	4	4.2	
OMS understandable		1		1	3	5	4.2	
OLO adequately reflected				2	3	5	4.6	
OLO understandable		1		1	3	5	4.2	
PPM adequately reflected				2	3	5	4.6	
PPM understandable		1		1	3	5	4.2	

PCM adequately reflected				2	3	5	4.6	I might add a little more detail to statement 19 – Project outcomes are generally predictable and quantitative tools are used for monitoring processes such as time, cost, and scope.
PCM understandable		1		1	3	5	4.2	
PPT adequately reflected				1	4	5	4.8	
PPT understandable		1		1	3	5	4.2	Might want to bold the "departmental" and "organizational strategic" words to differentiate statements 27 and 28 since the wording is very similar in these statements.
TDA adequately reflected				2	3	5	4.6	
TDA understandable		1		1	3	5	4.2	Consider adding detail to statements 31 and 32 – 31 – Tools to retrieve, cleanse, and analyze data are ad hoc and inconsistent. 32 – A data architecture strategy is in place, as are efforts to create organization-wide processes for data cleansing and ETL.
TDQ adequately reflected				3	2	4	4.4	
TDQ understandable		1		1	3	5	4.2	
TSG adequately reflected			1		4	5	4.6	
TSG understandable		1		1	3	5	4.2	
HCA adequately reflected				1	4	5	4.8	Be careful with the word operational. "Operational data" is often associated with Operational Data Scores (ODS) not data warehouses and BI.
HCA understandable		1		2	2	4	4.0	
HCC adequately reflected				2	3	5	4.6	
HCC understandable		1		1	3	5	4.2	
HCI adequately reflected			1	1	3	5	4.4	
HCI understandable		1		1	3	5	4.2	

HCE adequately reflected			2		3	5	4.2	
HCE understandable		1		1	3	5	4.2	

From the evaluation of the table above, it can be noted that all medians and means were 4 or above. There was a concern about how the words would be worded for the rating, which was dealt with in the Survey Monkey tool used to carry out the questionnaire. There were changes made from the initial draft based on the comments above as well as the researcher's attempt at providing clarity to the statements.

In addition to the BI participants evaluating the statements, a two-stage sorting procedure was also implemented to strengthen construct validity. This process has been used by researchers in the past to assist with verifying construct validity for survey questions (Agarwal, Xu, & Poo, 2011; Kankanhalli, Tan, & Wei, 2005; Moore & Benbasat, 1991). The first stage consisted of an unstructured sorting procedure and the second stage consisted of a structured sorting procedure of all the items in the organizational BI maturity assessment tool.

Unstructured Sorting

In the first stage, four graduate students (judges) who were not familiar with the research model and constructs were asked to sort all the randomized statements into an unrestricted number of categories. They were also asked to name each category. The unstructured sorting questionnaire can be found in Appendix H. If any statement appeared to be in more than one category, it could be included in more than one category, and if there appeared to be no category, then a 'no category' section could be created.

This process was very useful in identifying ambiguous words and clarifying the content of each statement. The names/categories that were given by the judges that were somewhat close were combined in the analysis into seven different categories. The percentages of answers that fell into each category for each statement were then combined (Shanshan, 2010). A matrix was created to determine how the judges grouped the statements into categories. The raw counts were grouped accordingly with percentages. The statements were then reordered according to the statements that had the highest percentages for each category. The results were then analyzed. The percentage results of the unstructured sorting process are listed in Table 14.

Table 14. Results of Unstructured Sorting

Q#	Statement/Category	BI	CM	DI	DQ	DS	LO	PT	PM
1	OVS1	50					25		
2	OVS2	50							
3	OVS3	50					25		
4	OVS4	50							
5	OVS5	50							
6	OMS1	50							
7	OMS2	50							
10	OMS5	50			50				
12	OLO2	50			50				
13	OLO3	50			25				
15	OLO5	50					25		
26	PPT1	50					25	25	
27	PPT2	50					25	25	
28	PPT3	50					25	25	
30	PPT5	50							
9	OMS4		50		50				
22	PCM2		50			25	25		
52	HCC2			25			25		
58	HCI3			25					
65	HCE5			25	25		25		
34	TDA4	25			100	25			
51	HCC1	25			100				
37	TDQ2		25		75				
55	HCC5				75	25			
44	TSG4				75	50			
11	OLO1	25	25		50	25	25		
36	TDQ1				50				
38	TDQ3				50	25			
39	TDQ4	25			50				
20	PPM5				50				25
54	HCC4				50	25	25		
59	HCI4	25			50				
35	TDA5				50	50			
61	HCE1				25	75			
62	HCE2		25			75			
63	HCE3					75	25		
41	TSG1				25	75			
31	TDA1		25		25	50			

42	TSG2		25			50	25		
16	PPM1		25						25
17	PPM2		25		25	25			25
18	PPM3				25				25
19	PPM4								25
29	PPT4	25	25				25	25	
8	OMS3	25							
14	OLO4	25			25			25	
21	PCM1	25	25		25				
23	PCM3		25			25			25
24	PCM4	25			25				
25	PCM5	25	25						
32	TDA2				25	25			
33	TDA3	25	25			25	25		
40	TDQ5	25			25			25	
43	TSG3				25	25			
45	TSG5				25	25	25		25
46	HCA1				25				
47	HCA2								
48	HCA3		25			25			
49	HCA4				25				
50	HCA5	25	25		25				
53	HCC3				25	25			
56	HCI1		25		25				
57	HCI2								
60	HCI5				25		25		
64	HCE4								

After a review of the unstructured sorting activity, it was apparent that some of the statements lacked clarity and should be restated. This was identified because the categories suggested for the statements did not always align with the intended categories. In addition, the Data Quality and Data Standardization and Governance categories were combined because the statements were closely related. Several changes were made to the statements and in the second stage a structured sorting activity was performed.

Structured Sorting

In the second stage, five graduate students (judges) who were not familiar with the research model and constructs were given the listing of the categories and were asked to insert the randomized reworded statements into the category that seemed to be the most appropriate without worrying about the number of statements that fell into each category. The questionnaire for the structured sorting activity is included as Appendix I. The same procedure for creating the matrix and reordering statements according to percentages that was used in the unstructured sorting was used in the structured sorting as well. The percentage results are listed in Table 15.

Table 15. Results of Structured Sorting

Statements/Category	OVS	OMS	OLO	PPM	PCM	PPT	TDA	TDQ	HCA	HCC	HCI	HCE
OVS1	100											
OVS4	100											
OVS5	100											
OVS2	67			33								
OVS3	67			33								
OLO2	67		33									
HCE2	67										33	
OMS3		100										
OMS4		100										
OMS1		67				33						
OMS2		67				33						
OMS5		67										33
OLO1			100									
OLO5			100									
OLO3	33		67									
PPM1				100								
PPM2				100								
PPM3				100								
PPM4				100								
PPM5				100								
PCM1					100							
PCM2					100							
PCM3					100							
PCM4					100							
PCM5			33		67							
PPT2						100						

PPT3						100						
PPT4						100						
PPT1	33					67						
PPT5				33		67						
TDA2							100					
OLO4			33				67					
TDA1							67			33		
TDA3							67	33				
TDA4							67				33	
TDA5			33				67					
TDQ1								100				
TDQ2								100				
TDQ3								100				
TDQ4								100				
TDQ5							33	67				
HCA3									100			
HCA4									100			
HCA5									100			
HCA2									67		33	
HCA1							33		33	33		
HCC5										100		
HCC1							33			67		
HCC2										67	33	
HCC3								33		67		
HCC4								33		67		
HCI2											100	
HCI5											100	
HCI3				33							67	
HCI4									33		67	
HCE5											67	33
HCE1							33					67
HCE3								33				67
HCE4											33	67
HCI1	33				33							33

It can be noted that after many of the statements were reworded and the judges were given the categories, the statements more closely reflected the categories and the results showed higher percentages of matching the categories. While this was better than the unstructured sorting results, the statements were again evaluated for clarity and reworded as appropriate.

The next step was to have a few staff members actually take the organizational BI maturity level assessment as a pilot study. Four staff members from one of the facilities involved in the case study were asked to participate. All were familiar enough with the organization to understand the statements. Because this was a small test group, the results were not tested for any statistical significance but for feedback on statement content and length of the overall assessment tool. The feedback did result in clarification of two statements. The participants involved in the pilot felt the assessment tool was quite easy to complete. The actual results of the full case study are discussed in the next chapter.

CHAPTER 5

DEMONSTRATION OF THE USEFULNESS OF THE PROPOSED HEALTHCARE BI MATURITY MODEL

Chapter 5 presents the results of the case study to determine the usefulness of the healthcare BI maturity model. The study took place in a healthcare organization comprised of multiple hospitals, clinics, long term care facilities, and home care agencies. The results of the quantitative organizational BI maturity assessment described in the previous chapter will be discussed along with a follow up from the short qualitative assessment with a few key stakeholders. The ultimate goal of the usefulness was to evaluate if the organizational BI maturity level assessment tool could be used to create a maturity level scoring for an organization.

Quantitative Organizational BI Maturity Level Assessment Results

The organizational BI maturity level assessment tool featured 60 statements about business intelligence in four core process areas. The survey targeted chief executive officers/administrators, chief financial officers, chief nursing officers, chief information officers/IT management, chief operating offers, medical information officers, project managers, business/clinical intelligence managers, and quality managers. The survey was distributed electronically to 72 stakeholders in the categories listed above within 14 different facilities. There were 60 statements on the survey featuring a five-point Likert scale, rated as strongly disagree, disagree, uncertain, agree, and strongly agree. There were a total of 12 dimensions covered in four core process areas. In addition, there was a comment section at the end of each section of statements for each of the five statements relating to a dimension. The 12 dimensions were categorized into variables and covered the four core process areas include:

1) Organizational Processes: BI vision and strategy (OVS), management engagement and support (OMS), and learning organization (OLO)

2) People and Team Processes: Project management (PPM), change management (PCM), and people and team skills (PPT)

3) Technology Processes: Data architecture (TDA) and data quality (TDQ)

4) Processes Specific to Healthcare Complexities: Healthcare – administrative and financial data (HCA), healthcare – clinical data (HCC), healthcare – integrated data (HCI), and healthcare – external data (HCE).

The actual organizational BI maturity level assessment tool is included as Appendix J. Each of the dimension sections was introduced with a short description or explanation of the dimension. The participants were given the choice of completing the questionnaire through an online automated tool or through a regular document template.

Of the 72 participants who were invited to complete the organizational BI maturity level assessment, 54 started the assessment, but only 47 participants completed the entire assessment, for a 65% completion rate. Figure 7 provides a summary of the type of facilities where participants work. Thirty-one or 57.4% of the participants who started the assessment were from the acute care hospital setting. The next largest category of participants was from the health system's corporate office, where 12 (22.2%) participants started the assessment. Other participants included 5 (9.3%) long term care, 4 (7.4%) ambulatory clinics, and 1 (1.9%) from a home care agency, and 1 (1.9) designated as 'Other.' There were four participants who stated they work in more than one facility.

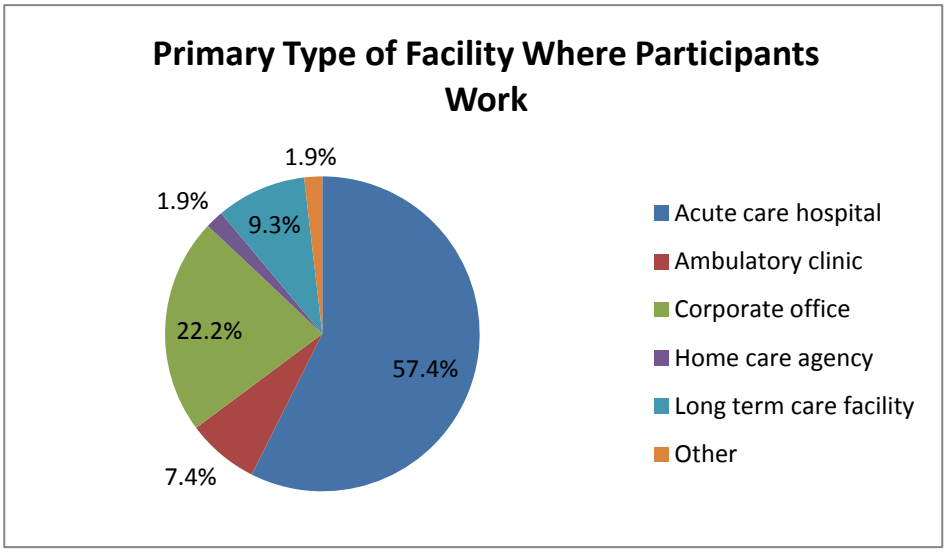


Figure 7. Pie Chart of Participants Primary Type of Work Facility

In addition to demographic information on the type of facility where participants worked, information was also gathered about the type of primary job responsibilities of the participants who

completed the organizational BI maturity level assessment. It is important information to keep in perspective who is taking the assessment and how they view the processes within the organization. Sixteen (or 29.6%) of the participants who completed the assessment were top level administration, followed by 6 (11.1%) in IT management, 5 (9.3%) in quality management, 4 (7.4%) in business/clinical intelligence, 4 (7.4%) in finance, 4 (7.4%) in nursing, 4 (7.4%) operational management, 4 (7.4%) physicians, 3 (5.6%) project managers, 1 (1.9%) in clinic operations management, and 3 (5.6%) who were listed as 'Other' actually assisted in completion of the assessment for one of the designees in the above categories. The information on primary job functions is shown in Table 16.

Table 16. Participant Primary Job Function

Job Function	Response Count	Response %
Business/Clinical Intelligence	4	7.40%
CEO/Administrator	16	29.60%
CFO/VP of Finance	4	7.40%
CIO/RIO/IT Management	6	11.10%
Clinic Operations Management	1	1.90%
CNO/VP of Nursing	4	7.40%
COO/VP of Operations	4	7.40%
Project Management	3	5.60%
Quality/Risk Management	5	9.30%
Physician/Medical Information Officer	4	7.40%
Other	3	5.60%
Total	**54**	

The first step in analyzing the results of the 60 Likert scale statements relative to business intelligence maturity was creating a table showing the counts and percentages of counts for each possible item answer for all 60 statements. The Likert results including strongly disagree (SD), disagree (D), uncertain (U), agree (A), and strongly agree (SA) are displayed in Table 17. When gathering the counts for each statement, it was noted that one participant had signed in to the assessment tool and completed demographic information only, but did not complete any of the statements. Therefore, that participant was actually deleted out of the counts in the raw data.

Table 17. Counts and Percentages for Likert Scale Statements Relating to BI Maturity

	SD	SD %	*D*	D %	*U*	U %	*A*	A %	*SA*	SA %	# *Responses*
OVS1	2	3.77%	15	28.30%	6	11.32%	26	49.06%	4	7.55%	53
OVS2	2	3.77%	20	37.74%	3	5.66%	27	50.94%	1	1.89%	53
OVS3	2	3.77%	14	26.42%	17	32.08%	19	35.85%	1	1.89%	53
OVS4	1	1.89%	15	28.30%	12	22.64%	24	45.28%	1	1.89%	53
OVS5	5	9.43%	21	39.62%	18	33.96%	8	15.09%	1	1.89%	53
OMS1	4	7.55%	13	24.53%	7	13.21%	26	49.06%	3	5.66%	53
OMS2	0	0.00%	20	37.74%	10	18.87%	22	41.51%	1	1.89%	53
OMS3	0	0.00%	5	9.43%	12	22.64%	32	60.38%	4	7.55%	53
OMS4	2	3.77%	27	50.94%	9	16.98%	15	28.30%	0	0.00%	53
OMS5	2	3.77%	33	62.26%	7	13.21%	11	20.75%	0	0.00%	53
OLO1	3	5.77%	10	19.23%	1	1.92%	32	61.54%	6	11.54%	52
OLO2	1	1.92%	4	7.69%	12	23.08%	33	63.46%	2	3.85%	52
OLO3	3	5.77%	28	53.85%	13	25.00%	8	15.38%	0	0.00%	52
OLO4	3	5.77%	28	53.85%	10	19.23%	11	21.15%	0	0.00%	52
OLO5	2	3.85%	16	30.77%	10	19.23%	22	42.31%	2	3.85%	52
PPM1	3	5.88%	7	13.73%	10	19.61%	29	56.86%	2	3.92%	51
PPM2	1	1.96%	15	29.41%	13	25.49%	22	43.14%	0	0.00%	51
PPM3	1	1.96%	22	43.14%	12	23.53%	15	29.41%	1	1.96%	51
PPM4	1	1.96%	15	29.41%	8	15.69%	26	50.98%	1	1.96%	51
PPM5	2	3.92%	13	25.49%	16	31.37%	19	37.25%	1	1.96%	51
PCM1	2	4.08%	13	26.53%	4	8.16%	26	53.06%	4	8.16%	49
PCM2	1	2.04%	5	10.20%	7	14.29%	35	71.43%	1	2.04%	49
PCM3	4	8.16%	35	71.43%	4	8.16%	6	12.24%	0	0.00%	49
PCM4	2	4.08%	28	57.14%	8	16.33%	11	22.45%	0	0.00%	49
PCM5	0	0.00%	8	16.33%	4	8.16%	30	61.22%	7	14.29%	49
PPT1	1	2.08%	8	16.67%	11	22.92%	28	58.33%	0	0.00%	48
PPT2	0	0.00%	12	25.00%	17	35.42%	19	39.58%	0	0.00%	48
PPT3	0	0.00%	21	43.75%	17	35.42%	10	20.83%	0	0.00%	48
PPT4	3	6.25%	21	43.75%	15	31.25%	9	18.75%	0	0.00%	48
PPT5	0	0.00%	21	43.75%	16	33.33%	11	22.92%	0	0.00%	48
TDA1	2	4.17%	7	14.58%	5	10.42%	28	58.33%	6	12.50%	48
TDA2	3	6.25%	10	20.83%	17	35.42%	16	33.33%	2	4.17%	48
TDA3	2	4.17%	16	33.33%	19	39.58%	11	22.92%	0	0.00%	48
TDA4	5	10.42%	18	37.50%	10	20.83%	15	31.25%	0	0.00%	48
TDA5	11	22.92%	23	47.92%	8	16.67%	6	12.50%	0	0.00%	48
TDQ1	2	4.17%	3	6.25%	4	8.33%	31	64.58%	8	16.67%	48
TDQ2	0	0.00%	3	6.25%	2	4.17%	35	72.92%	8	16.67%	48

TDQ3	0	0.00%	25	52.08%	15	31.25%	8	16.67%	0	0.00%	48
TDQ4	1	2.08%	23	47.92%	17	35.42%	7	14.58%	0	0.00%	48
TDQ5	4	8.33%	18	37.50%	13	27.08%	13	27.08%	0	0.00%	48
HCA1	1	2.08%	5	10.42%	6	12.50%	26	54.17%	10	20.83%	48
HCA2	1	2.08%	8	16.67%	14	29.17%	24	50.00%	1	2.08%	48
HCA3	1	2.08%	13	27.08%	16	33.33%	16	33.33%	2	4.17%	48
HCA4	1	2.08%	7	14.58%	12	25.00%	25	52.08%	3	6.25%	48
HCA5	1	2.08%	8	16.67%	11	22.92%	24	50.00%	4	8.33%	48
HCC1	0	0.00%	6	12.50%	9	18.75%	30	62.50%	3	6.25%	48
HCC2	0	0.00%	5	10.42%	15	31.25%	27	56.25%	1	2.08%	48
HCC3	1	2.08%	9	18.75%	16	33.33%	21	43.75%	1	2.08%	48
HCC4	1	2.08%	8	16.67%	10	20.83%	27	56.25%	2	4.17%	48
HCC5	1	2.08%	3	6.25%	7	14.58%	32	66.67%	5	10.42%	48
HCI1	1	2.13%	14	29.79%	8	17.02%	24	51.06%	0	0.00%	47
HCI2	0	0.00%	12	25.53%	15	31.91%	20	42.55%	0	0.00%	47
HCI3	0	0.00%	12	25.53%	16	34.04%	18	38.30%	1	2.13%	47
HCI4	1	2.13%	13	27.66%	11	23.40%	18	38.30%	4	8.51%	47
HCI5	0	0.00%	16	34.04%	13	27.66%	13	27.66%	5	10.64%	47
HCE1	1	2.13%	9	19.15%	9	19.15%	22	46.81%	6	12.77%	47
HCE2	0	0.00%	0	0.00%	20	42.55%	24	51.06%	3	6.38%	47
HCE3	1	2.13%	6	12.77%	11	23.40%	27	57.45%	2	4.26%	47
HCE4	3	6.38%	10	21.28%	16	34.04%	16	34.04%	2	4.26%	47
HCE5	2	4.26%	21	44.68%	20	42.55%	4	8.51%	0	0.00%	47
Total	**100**		**844**		**674**		**1220**		**122**		**2960**

It is important to distinguish between Likert-type items and Likert scales. Likert-type items are single questions that include responses using a Likert scale. The questions in the research instrument are not necessarily related and are not combined into a composite score to measure a particular variable (Clayson & Dormody, 1994). On the other hand, Likert-scale items use a Likert scale for measurement and four or more of the questions are related to each other. The related questions are calculated as a composite score (or variable). In this research, the Likert scale items are composed of a series of five statements which make up each variable (dimension from the maturity model). The series of questions are then combined into a single composite (or variable) when the data is analyzed. It is important to make this distinction prior to the analysis of the data because the statistics that are used to analyze the data are different. Likert type data is analyzed with the ordinal scale measurement while the composite scores of Likert scale data are analyzed at the interval measurement scale. (Boone & Boone, 2012)

In the organizational BI maturity level assessment tool used in this research, a composite score was developed for each set of 12 variables (or maturity model dimensions). This was used in the maturity level scoring as well. The maturity scoring process will be discussed later in this chapter. When the organizational BI maturity level assessment tool was designed, for each dimension, the Level 1 statement was the first one listed for that particular dimension. Each additional statement went up one level. The statements were developed based on the descriptions defined in the finalized healthcare BI maturity model that was developed through the iterative feedback from the BI participant group. An example of the BI vision and strategy statements for each corresponding level of maturity is listed in Table 18.

Table 18. Example of Maturity Level Statements

Dimension	Code	Level	Question
BI Vision and Strategy	OVS1	1	BI initiatives and responsibilities are decentralized within the organization.
	OVS2	2	Our organization may have some BI initiatives in place, but they are not consistently aligned with the organizational vision and strategy.
	OVS3	3	Our organization has defined standards for the development and operations of BI initiatives which are aligned with organizational vision and strategy.
	OVS4	4	Within our organization, BI initiatives include measured targets or performance that relate back to organizational vision and strategy.
	OVS5	5	Our organization has a comprehensive documented BI strategy driven by business objectives.

The answers in the organizational BI maturity level assessment tool were answered as strongly disagree, disagree, uncertain, agree, or strongly agree. It can be noted from Table 18, that the statements relating to Level 1 and 2 maturities are actually reverse in meaning from the overall direction of the scale. This is referred to as reverse wording. Therefore, prior to actually computing the scale for the mean of a series of statements, the counts for Levels 1 and 2 were assigned the reverse value. For example, if a respondent answered "strongly agree" (SA) for the OVS1 statement, they would be assigned a count in the "strongly disagree" SD item. If a respondent answered "strongly disagree" (SD) to the OVS1 statement, they would be assigned a count in the "strongly agree" item. The scoring to the Likert responses to capture the reverse wording followed the logic below:

Level 1	Example OVS1	SD = SA, D = A, U = U, A = D, SA = SD
Level 2	Example OVS2	SD = SA, D = A, U = U, A = D, SA = SD
Level 3	Example OVS3	SD = SD, D = D, U = U, A = A, SA = SA

Level 4 Example OVS4 SD = SD, D = D, U = U, A = A, SA = SA

Level 5 Example OVS5 SD = SD, D = D, U = U, A = A, SA = SA

The results of the means and standard deviations for the adjusted scale because of reverse wording are displayed in Table 19. It can be noted that the standard deviations range from 0.61 to 1.12, but most are less than 1.00 or around 1.00. A standard deviation of 1 indicates that 68% of the responses are within 1 standard deviation from the mean. The smaller the standard deviation, the closer the responses are to the mean.

Table 19. Adjusted Scale Descriptive Statistics

Variable	N	Mean	StDev	Minimum	Maximum
OVS1 ADJ	53	2.72	1.08	1.00	5.00
OVS2 ADJ	53	2.91	1.06	1.00	5.00
OVS3	53	3.06	0.93	1.00	5.00
OVS4	53	3.17	0.94	1.00	5.00
OVS5	53	2.60	0.93	1.00	5.00
OMS1 ADJ	53	2.79	1.12	1.00	5.00
OMS2 ADJ	53	2.92	0.94	1.00	4.00
OMS3	53	3.66	0.76	2.00	5.00
OMS4	53	2.70	0.93	1.00	4.00
OMS5	53	2.51	0.87	1.00	4.00
OLO1 ADJ	52	2.46	1.11	1.00	5.00
OLO2 ADJ	52	2.40	0.77	1.00	5.00
OLO3	52	2.50	0.83	1.00	4.00
OLO4	52	2.56	0.89	1.00	4.00
OLO5	52	3.12	1.02	1.00	5.00
PPM1 ADJ	51	2.61	0.98	1.00	5.00
PPM2 ADJ	51	2.90	0.90	2.00	5.00
PPM3	51	2.86	0.94	1.00	5.00
PPM4	51	3.22	0.97	1.00	5.00
PPM5	51	3.08	0.93	1.00	5.00
PCM1 ADJ	49	2.65	1.09	1.00	5.00
PCM2 ADJ	49	2.39	0.79	1.00	5.00
PCM3	49	2.24	0.78	1.00	4.00
PCM4	49	2.57	0.89	1.00	4.00
PCM5	49	3.73	0.91	2.00	5.00
PPT1 ADJ	48	2.63	0.84	2.00	5.00
PPT2 ADJ	48	2.85	0.80	2.00	4.00
PPT3	48	2.77	0.78	2.00	4.00
PPT4	48	2.63	0.87	1.00	4.00

PPT5	48	2.79	0.80	2.00	4.00
TDA1 ADJ	48	2.40	1.03	1.00	5.00
TDA2 ADJ	48	2.92	0.99	1.00	5.00
TDA3	48	2.81	0.84	1.00	4.00
TDA4	48	2.73	1.03	1.00	4.00
TDA5	48	2.19	0.94	1.00	4.00
TDQ1 ADJ	48	2.17	0.93	1.00	5.00
TDQ2 ADJ	48	2.00	0.68	1.00	4.00
TDQ3	48	2.65	0.76	2.00	4.00
TDQ4	48	2.63	0.76	1.00	4.00
TDQ5	48	2.73	0.96	1.00	4.00
HCA1 ADJ	48	2.19	0.96	1.00	5.00
HCA2 ADJ	48	2.67	0.86	1.00	5.00
HCA3	48	3.10	0.93	1.00	5.00
HCA4	48	3.46	0.90	1.00	5.00
HCA5	48	3.46	0.94	1.00	5.00
HCC1 ADJ	48	2.38	0.79	1.00	4.00
HCC2 ADJ	48	2.50	0.71	1.00	4.00
HCC3	48	3.25	0.86	1.00	5.00
HCC4	48	3.44	0.90	1.00	5.00
HCC5	48	3.77	0.81	1.00	5.00
HCI1 ADJ	47	2.83	0.94	2.00	5.00
HCI2 ADJ	47	2.83	0.82	2.00	4.00
HCI3	47	3.17	0.84	2.00	5.00
HCI4	47	3.23	1.03	1.00	5.00
HCI5	47	3.15	1.02	2.00	5.00
HCE1 ADJ	47	2.51	1.02	1.00	5.00
HCE2 ADJ	47	2.36	0.61	1.00	3.00
HCE3	47	3.49	0.86	1.00	5.00
HCE4	47	3.09	1.00	1.00	5.00
HCE5	47	2.55	0.72	1.00	4.00

The next step was to create the means and standard deviations for the 12 dimensions. There were five statements asked for each of the 12 dimensions. The means and standard deviations of the dimensions are shown in Table 20. It can be noted that the means and standard deviations are quite similar for each of the 12 dimensions.

Table 20. Descriptive Statistics for the 12 Dimensions

Variable	N	Mean	StDev	Minimum	Maximum
OVS	265	2.89	1.00	1.00	5.00
OMS	265	2.92	1.00	1.00	5.00
OLO	260	2.61	0.96	1.00	5.00
PPM	255	2.93	0.96	1.00	5.00
PCM	245	2.72	1.04	1.00	5.00
PPT	240	2.73	0.82	1.00	5.00
TDA	240	2.61	1.00	1.00	5.00
TDQ	240	2.43	0.87	1.00	5.00
HCA	240	2.98	1.03	1.00	5.00
HCC	240	3.07	0.97	1.00	5.00
HCI	235	3.04	0.94	1.00	5.00
HCE	235	2.80	0.95	1.00	5.00

The items in the overall survey were evaluated for internal consistency with Cronbach's alpha. Cronbach's alpha is a reliability measure to determine how closely related a set of items are in a group. A reliability coefficient of .70 or higher is usually considered acceptable. The overall Cronbach's alpha was .86, which would indicate an acceptable level of internal consistency. Additional calculations captured the Cronbach's alpha for the subscales (or process areas) for organizational processes, people and team processes, technology processes, and healthcare processes. It can be noted in Table 21 that each of the categories has a smaller Cronbach's alpha than the overall calculation. However, alpha can be affected by the number of items in a scale. (Cortina, 1993). For further assessment testing done beyond this research study, an evaluation of the content of some of the specific statements in the assessment tool should be evaluated.

Table 21. Cronbach's Alpha for 4 General Process Areas

Process/Dimension	Cronbach's Alpha
Organizational Processes	0.69
People and Team Processes	0.67
Technology Processes	0.62
Healthcare Processes	0.57
Overall	**0.86**

The results were then divided into two groups representing data users and data providers to evaluate potential perception differences. The data users included users of reports including upper

management and physicians. The data providers include areas generally involved in providing the information, including business intelligence, IT, quality, and project management.

Table 22. Dimension Results of Data Users

Variable	N	Mean	StDev	Minimum	Maximum
OVS	175	2.92	1.02	1.00	5.00
OMS	175	2.99	0.99	1.00	5.00
OLO	170	2.59	0.93	1.00	5.00
PPM	165	2.96	0.93	1.00	5.00
PCM	155	2.83	1.01	1.00	5.00
PPT	155	2.79	0.81	1.00	5.00
TDA	155	2.60	0.90	1.00	5.00
TDQ	155	2.45	0.85	1.00	5.00
HCA	155	2.97	0.99	1.00	5.00
HCC	155	3.09	0.92	1.00	5.00
HCI	150	2.91	0.91	2.00	5.00
HCE	150	2.81	0.89	1.00	5.00

The results of the data users and data providers are provided in Tables 22 and 23 respectively with Figure 8 showing a graph of the same information. In general, the data users tended to score higher than the data providers in the organizational and people and team processes but lower in technical architecture and most of the of the healthcare process areas. In both cases, the lowest mean was the data quality (TDQ) dimension.

Table 23. Dimension Results of Data Providers

Variable	N	Mean	StDev	Minimum	Maximum
OVS	90	2.83	0.97	1.00	5.00
OMS	90	2.78	1.01	1.00	5.00
OLO	90	2.64	1.02	1.00	5.00
PPM	90	2.88	1.02	1.00	5.00
PCM	90	2.53	1.06	1.00	5.00
PPT	85	2.62	0.82	1.00	4.00
TDA	85	2.62	1.15	1.00	5.00
TDQ	85	2.40	0.92	1.00	5.00
HCA	85	2.98	1.11	1.00	5.00
HCC	85	3.02	1.07	1.00	5.00
HCI	85	3.27	0.96	1.00	5.00
HCE	85	2.78	1.04	1.00	5.00

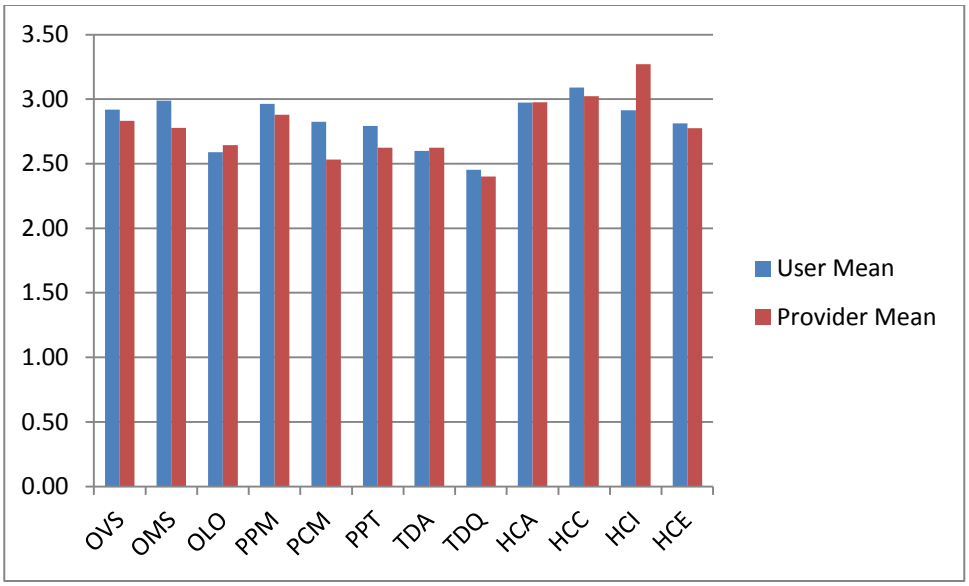


Figure 8. Data User vs. Data Provider Means of each Dimension

A two-sample t-test was used to determine if there was a significant difference between the sample means. Distribution can be considered sufficient as long as the frequency distributions have a mound shape (Iowa). The larger the t-value, the smaller the probability that the means of the two populations are the same. The absolute value (positive or negative) should be used when interpreting the t-value because it doesn't matter if the t-value is negative or positive. The p-value approach of evaluation then takes the value of the t-value and computes a probability. The probability, or p-value, provides a measure of the evidence against the null hypothesis provided by the sample (Anderson, Sweeney, & Williams, 2009). Smaller p-values indicate more evidence against the null hypotheses. The general rule is to reject the null hypothesis if the p-value is less than or equal to the level of significance α. In this particular case, $\alpha = .05$. The hypothesis to evaluate the sample means was set up as follows:

1. Null hypothesis (H_o): The two populations have the same mean.
2. Alternative hypothesis (H_1): The two populations do not have the same mean and are significantly different.

   Reject H_o if p-value $\leq \alpha$.

The t-values and p-values that were calculated from the means and standard deviations between the data user and data provider groups are shown in Table 24. The unequal sample size was taken into consideration by using the Satterthwaithe approximation.

Table 24. Two-Sample T-Tests for Data User and Data Provider Groups

Dimension	T-value	P-Value	Reject H_o if p-value $\leq$ α (or .05)
OVS	0.67	0.50	Fail to Reject H_0
OMS	1.61	0.11	Fail to Reject H_0
OLO	-0.44	0.66	Fail to Reject H_0
PPM	0.66	0.51	Fail to Reject H_0
PCM	2.12	0.04	Reject H_0
PPT	1.55	0.12	Fail to Reject H_0
TDA	-0.16	0.87	Fail to Reject H_0
TDQ	0.43	0.67	Fail to Reject H_0
HCA	-0.02	0.99	Fail to Reject H_0
HCC	0.49	0.63	Fail to Reject H_0
HCI	-2.80	0.01	Reject H_0
HCE	0.27	0.78	Fail to Reject H_0

Based on the results of the t-value testing, the dimensions of change management and integrated healthcare processes were considered to have significantly different means between the data user and the data provider groups. In the change management area, data users had a mean of 2.83 while the data providers had a mean of 2.53. In the integrated healthcare process area, the data users had a mean of 2.91 while the data providers had a mean of 3.27. A similar analysis of users and providers combined the dimensions into the four specific processes. Table 25 displays the data user information while Table 26 displays information for the data providers. In addition, Figure 9 shows a graph comparing the results of the information in graphic format.

Table 25. Data User Information for Four Process Areas

Variable	N	Mean	StDev	Minimum	Maximum
U-ORG	520	2.83	1.00	1.00	5.00
U-PPT	475	2.86	0.92	1.00	5.00
U-TECH	310	2.53	0.88	1.00	5.00
U-HC	610	2.95	0.93	1.00	5.00

Table 26. Data Provider Information for Four Process Areas

Variable	N	Mean	StDev	Minimum	Maximum
P-ORG	270	2.75	1.00	1.00	5.00
P-PPT	265	2.68	0.98	1.00	5.00
P-TECH	170	2.51	1.04	1.00	5.00
P-HC	340	3.01	1.06	1.00	5.00

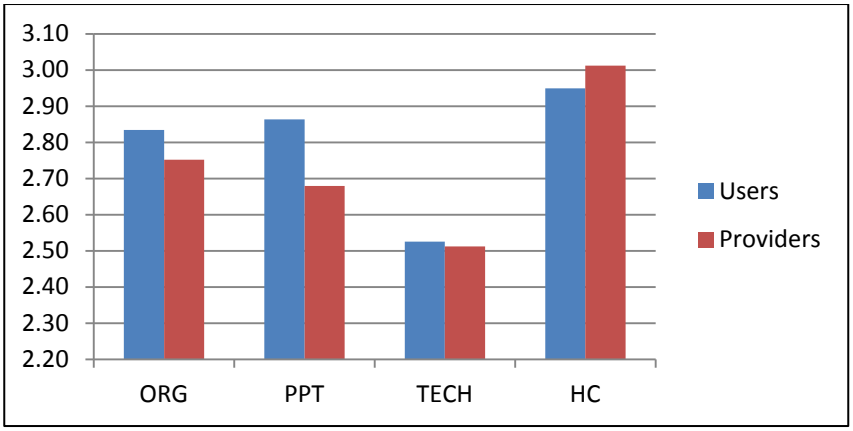


Figure 9. Data User vs. Data Provider Means for Four Process Areas

It can be noted that the data users tended to score higher on the organizational and people/team processes, but lower on the healthcare processes. It could be because this particular group feels as though they have more insight into the organizational and people/team processes. It can also be noted the lowest process area for both groups was the technical area, including technology infrastructure and data quality.

Table 27. Four Process Areas Combined

Variable	N	Mean	StDev	Minimum	Maximum
ORG	777	2.82	1.00	1.00	5.00
PPT	740	2.80	0.95	1.00	5.00
TECH	480	2.52	0.94	1.00	5.00
HC	950	2.97	0.98	1.00	5.00

Table 27 provides the means to the four process areas, regardless of the breakdown of data users versus data providers. The scores are the combination of all the dimensions included in each particular process area.

Method for Maturity Level Scoring

The final step in the data analysis was to determine a maturity level for the organization based on the results of the organizational BI maturity level assessment. When using the staged approach, the maturity level determined is the highest level at which all process areas contained within the maturity level, and within all lower maturity levels, are satisfied (SEI, 2006). When using the staged approach, high maturity is achieved at Levels 4 and 5. Achieving Level 4 involves implementing all process areas for maturity levels 2, 3, and 4. Achieving Level 5 involves implementing all process areas for Levels 2, 3, 4, and 5 (SEI, 2010). It should be noted that when following CMMI as an example, there are five maturity levels, but ratings are only awarded for stages 2 through 5. A staged approach typically reviews only a manageable number of processes at one time. This maturity model was developed to review all 12 dimensions within the four process areas at the same time. Therefore, the maturity score is the highest level of an entire process area, provided the lower levels within each dimension score are satisfied.

Each question was calculated as follows: The counts for each Likert response were multiplied by the number assigned above. The responses for each question were totaled and divided by the number of responses to determine the average score for the question. A sum of all statements within each dimension was then divided by the total number of responses for each statement to determine the average score for each question. Because the Likert scores were reversed for the earlier analysis and there are the same number of maturity levels as there are Likert scales, the methodology for the average of the weighted sums is the same. Therefore, the means of the statistical calculations above were used. The review of the process areas yielded the results shown in Table 28. The healthcare process area had the highest overall process area score at 3.07. However, the highest level that all dimensions within the healthcare process area as well as all process and dimension areas had reached is a Level 2, which makes the overall maturity level for this organization a Level 2.

When the organizational BI maturity level assessment was given, there was an opportunity for comments for each dimension. The purpose of the comments was to give feedback on the content of the statements themselves as well as comments on the participants' perceptions of BI maturity for that particular dimension area. The entire list of comments from the organizational BI maturity level assessment is displayed in Appendix K. They were very helpful in providing insight and perspective from the organization used in this case study. The comments for this particular

case study tend to reflect an organization where BI is evolving. This is in line with a lower level maturity score, which was reflected in the quantitative BI maturity level assessment results.

Table 28. Maturity Level Scoring Results for Case Study

Process Area	Variable	Mean	Highest Score in Process Area	Highest Complete Level in Process Area
Organization			2.92	**2**
	OVS	2.89		
	OMS	2.92		
	OLO	2.61		
People/Team			2.93	**2**
	PPM	2.93		
	PCM	2.72		
	PPT	2.73		
Technology			2.61	**2**
	TDA	2.61		
	TDQ	2.43		
Healthcare			3.07	**2**
	HCA	2.98		
	HCC	3.07		
	HCI	3.04		
	HCE	2.80		

Qualitative BI Maturity Level Assessment Results

The last step in the assessment process was to follow up with a very short qualitative BI maturity level assessment with a few key stakeholders to gather a little broader perspective of the BI initiatives/direction about the organization that may not be gathered from a quantitative organizational BI maturity level assessment. The purpose of the follow up was also to determine if their thoughts/perspectives appeared to be in line with the results of the quantitative organizational BI maturity assessment. The plan was to initially do an interview with five stakeholders; however, participants taking the quantitative BI maturity level assessment were taking anywhere from six minutes to two hours to complete the survey; therefore, the researcher was hesitant to ask for too much additional time for a qualitative follow up.

The stakeholders that were interviewed included representation from high-level IT management, business/clinical intelligence, and a physician information officer. The comments

that were openly given by survey participants in the quantitative BI maturity level assessment also added much insight into BI questions/issues within the organization.

The researcher spent some time going through the five levels of maturity and processes being proposed in the maturity model before asking questions. The four questions and answers are listed below:

Q1: Based on the five levels of maturity being proposed, what would be your perceived level of maturity for this organization and why?

P1: Any one facility could probably score fairly high. However, as an organization, we are fairly immature in our consolidated processes. I would say probably a Level 1 for the entire organization.

P2: From a clinical intelligence perspective, I think we are quite high on the maturity level. But I don't think our overall processes are that high.

P3: I would guess a Level 3. The biggest problems I see are consistency in standards across many aspects of the organization. I also think we have data, but we don't have people that know what to do with it. We are not good on using statistical analysis and good follow through and communication at all levels of the organization.

Q2: Based on the four general process areas being proposed, where do you feel the organization will score the highest and why?

P1: Probably People and Team. The fact that we have a structured project management process has helped bring structure to other processes within the organization.

P2: Healthcare complexities – We have a lot of different systems in place and are making integration of information a priority.

P3: Some organizational and some people and team – The organization at the top level seems to understand what is going on as far as data analysis, but we don't filter all the information down, so the people actually needing to evaluate the information don't always know what to do. We are not so good at follow up.

Q3: Of the four general process areas listed above, where do you feel the organization will score the lowest and why?

P1: Organizational processes – We tend to be too operational and not as visionary and strategic as we need to be.

P2: Technology – It is hard to get the data out and scrubbed well. There are many inconsistencies in the data as it exists today. We need a lot more work on data standardization.

P3: People and team – We need to work on developing a culture of change.

Q4: What would you predict would be the biggest challenges in business intelligence in healthcare over the next 2-3 years?

P1: Providing the right analytics for those with chronic disorders. We really need to focus on what is the right information at the right time for the people who are really sick.

P2: Standardized data definitions so data can be reported to many different types of facilities and agencies.

P3: Getting information in the system correctly the first time without adding a lot of additional steps. We need to work these data elements into the workflow. Also motivating people to accept change is and will continue to be a challenge.

In general, the qualitative assessment results showed some inconsistencies among the stakeholders who were interviewed. The perceived maturity levels were low to midrange, which was in line with the results of the quantitative BI maturity level assessment. There appeared to be differing opinions on the process areas which were the lowest and highest. Again, this is not necessarily surprising since the maturity level score is quite low and BI appears to just be evolving within the organization. The answers to the perceived challenges in BI over the next 2-3 years varied considerably. This is probably due to the very different perspectives and backgrounds of the stakeholders who were interviewed.

Reliability and Validity

Several efforts were made to ensure reliability and validity within the overall maturity model development as well as the evaluation of the model itself. Prior to developing the model, several existing models were evaluated to determine the purpose, processes, dimensions, maturity levels, and method of evaluation. These were evaluated against the complexities in healthcare to determine if an existing model could capture the complexities without the use of a third party manipulating questions to make them more specific to healthcare. Once the gap analysis was

completed, a maturity model was created with reliability and validity as top concerns throughout the development and evaluation.

Instrument reliability is a measure of consistency in the questions making up a scale or subscale (Blessing & Forister, 2013). When developing the organizational BI maturity level assessment tool, both BI participants and judges were involved in reviewing and giving feedback on the questions and sorting of questions into categories. This greatly assisted with rewording of questions so the answers would be consistent. After the organizational BI maturity level assessment was given, a Cronbach's alpha was analyzed for each dimension as well as overall process areas to determine the reliability of the statements within the organizational BI maturity level assessment tool.

Face validity addresses the question, "Does the particular measurement or method appear to be appropriate?" (Blessing & Forister, 2013). Face validity was addressed in the maturity model creation by using the group of BI participants to provide iterative input and feedback on the maturity model that was being developed. In addition, the BI participants were asked to review the statements being considered in the BI maturity level assessment relative to the purpose and leveling of the new maturity model as a method of addressing face validity in the evaluation tool.

Content validity asks whether the test is broad enough to address the scope of the content. In the maturity model development, this was covered in the summative evaluation of the BI participants when they were asked to give feedback to determine if the problem requirements were actually being met through the maturity model development. In the evaluation tool, the participants in the case study were given an opportunity to provide comments on each section. The comments were reviewed to determine if there could be gaps in content or understanding that should be considered in refinement of a future evaluation tool.

Criterion validity is an indication of how well the test performs. In the maturity model creation, this was accomplished with both the formative and summative evaluation. In the formative evaluation, the BI participants were asked to evaluate the problem requirements for a healthcare BI maturity model. These problem requirements were then evaluated against existing maturity models to determine if they were met through a model that had already been created. In the summative evaluation, the BI participants were asked to evaluate if the model met the problem requirements that were initially identified. This was evaluated for soundness in the organizational BI maturity level assessment tool by analyzing the overall results including the means, standard

deviations, and t-tests. The information was presented in data and chart formats in an effort to make the information easier to analyze.

Construct validity assesses the degree to which the measurement is based on theory. During the maturity model creation, past models that included any type of underlying theory were evaluated for the processes, dimensions, and maturity definitions for each dimension level. In addition, the critical success factors that had previously been identified for the success of BI were reviewed. Several methods were carried out to evaluate the construct of statements in the evaluation tool. Prior to developing the statements for the organizational BI maturity level assessment, a rather rigorous review was done to determine if similar questions had been asked in past surveys, and if so, if all or part of the question could be used within this questionnaire. The two-stage sorting procedure was used to evaluate the construct of the statements and ensure they closely matched the dimensions and process areas. In addition, in the summative evaluation, BI participants had an opportunity to provide feedback on the construction of the statements. The participants taking the actual organizational BI maturity level assessment were also given an opportunity to provide feedback on statement construction.

The attempt to overcome the external validity threat of generalizability was considered in both the model creation and evaluation tool. In the model creation, the problem requirements were created to cover many different aspects and types of healthcare business models. In the evaluation tool, the statements were purposely created broad enough to be able to be used to address many types of facilities or healthcare business models. Several hospitals, nursing homes, home care agencies, and clinics within the healthcare organization were included as a part of the case study that used the evaluation tool. The case study also consisted of key stakeholders that included a broad representation of senior level managers both as users and providers of the data.

CHAPTER 6

DISCUSSION AND CONCLUSION

This chapter provides an overall evaluation of the research as well as the potential impact. A review of the results of both the evaluation and demonstration will be discussed. Limitations of the research as well as recommendations for future research will be presented. The contributions to research and overall conclusions bring a close to the chapter.

Reflection on Healthcare BI Maturity Model Creation and Demonstration

The process to create the healthcare BI maturity model and an organizational assessment tool were quite rigorous. The design science methodology was followed for the BI maturity model creation. This began with a rigorous understanding of the problem requirements and ended in demonstrating that the model could be used in a real-life scenario.

A very thorough literature review on both existing maturity models and healthcare complexities demonstrated there may be a need for a BI maturity model just for healthcare usage. Problem requirements were developed and validated with the BI participant group. The iterative maturity model development with the BI participants helped validate the processes, dimensions, and functionality components for each maturity level. Both a formative and summative evaluation were completed by the BI participant group to make sure problem requirements were identified and were met in the model that was developed. The feedback was positive; therefore, attention then turned to creating and validating the use of an organizational BI maturity level assessment tool.

The organizational BI maturity level assessment tool was created by taking statements from the maturity model and including them in a Likert scale type questionnaire. The overall purpose of the assessment tool would be to evaluate questionnaire results from an organization and calculate a BI maturity score. The BI participants as well as a group of graduate students were instrumental in evaluating the soundness of the organizational BI maturity level assessment tool.

The BI participants who helped develop the model were asked to review the statements in the organizational BI maturity level assessment tool to determine if each maturity level and dimension were adequately represented for each process area and if the questions were presented in

an understandable format. The results of their review resulted in a very positive evaluation by the BI participants. However, a few changes were suggested and made.

The second method for reviewing the soundness of the organizational BI maturity level assessment tool was through the use of an unstructured and structured sorting procedure. During the unstructured process, the participants had to blindly categorize the proposed BI maturity level assessment statements. This resulted in rewording of several statements to make them easier to understand and more closely fit the intended category of statements. In the second portion of the process, all statements were again reviewed with the categories of statements listed. The participants were asked to insert the reworded statements into the appropriate category. This resulted in the rewording of a few more statements, but overall, the results were much better after the statements were reworded the first time and the participants were actually given the category names for consideration. Between the two processes for verifying that the problem requirements for the model and the reviewing the organizational BI maturity level assessment tool for cohesiveness and content, it was felt these were adequate methods to include in the evaluation process.

The purpose of the demonstration was to determine the usefulness of the model and corresponding organizational BI maturity level assessment tool could be used in a real-life scenario. A case study was performed in a healthcare system which was comprised of multiple hospitals, nursing homes, home care agencies, and clinics. The organizational BI maturity level assessment was sent to key stakeholders including senior level management, medical information officers, IT leadership, business and clinical intelligence leaders, and quality leaders. The assessment tool included 60 statements about each of the 12 dimensions within the maturity model. The results of the survey were reviewed for internal consistency, perception differences between a data user and provider group, a comment section review, and ultimately, a BI maturity score designation.

The means, standard deviations, and Cronbach's alpha were reviewed for each dimension. Everything seemed to be relatively consistent. The Cronbach's alpha is considered acceptable if it is greater than .70. In this case, the overall Cronbach's alpha was greater than .70.

The results were then broken into two groups, classified as data users and data providers. The data user group consisted of senior level management and medical information officers while the data provider group consisted of IT and project management leadership, business and clinical intelligence leaders, and quality managers. The purpose of reviewing these two groups was to

determine if the perception of business intelligence maturity varied depending on the user's general knowledge or perception within the four broad process areas. While there were slight differences, the two areas that had a significant difference were change management and the healthcare integrated processes, where the data users tended to have a higher perception of change management and a lower perception of the integration of administrative, financial, and clinical data than the data providers. This could very well be because the data users are more closely involved with change management but the data providers are more closely involved with the data on a daily basis. The data users may not realize the level of integration that is being done through interfaces or data mapping.

Reviewing the comments that were given by the participants was extremely helpful. First of all, there were a handful of statements that stated the statement was confusing or badly worded. These will be reviewed prior to any other distribution of the organizational BI maturity level assessment tool. The bulk of the statements appeared to be a very honest representation of where participants felt the organization was at in terms of maturity of various process areas. Common issues identified include overall consistency, evolving strategy, resources, communication, training, and data quality. When reviewing the comments and comparing the organizational means and the maturity level of the organization, everything seemed to point to the same general level of maturity.

A very short qualitative maturity level assessment interview was completed at the end of the survey with three stakeholders in different areas including IT, business and clinical intelligence, and physician leadership. The purpose of the interview was to determine if their perception of high and low process areas were consistent with the overall results. The answers to the four questions were quite different, but in all cases, they appeared to recognize the lower maturity levels that were expressed in the organizational BI maturity level assessment and general comments by the participants.

The overall maturity score was determined for the organization in this study was a Level 2. This appeared consistent with the general comments that were expressed by the participants, such as evolving strategy, inconsistency in many process areas, and data quality. In general, the researcher was comfortable that the functionality at each maturity level was reflected in the statements in the organizational BI maturity level assessment. It was also felt that the results of the quantitative organizational BI maturity level assessment and qualitative maturity level assessment interviews

adequately reflected the maturity level of the organization based on the evaluation of the results and reflection on the comments.

Limitations and Recommendations for Future Research

This research attempted to determine if a domain specific maturity model was necessary to measure business intelligence maturity in healthcare, as well as to determine what the components of the model should include. The researcher provided rigorous background information to solidify the dimensions and functionality at each maturity level. Input was received from a group of BI participants who had a variety of experience either within healthcare or business intelligence. Because of the limited number of BI participants and the limited amount of time to give constructive feedback, the input into the model creation itself could possibly vary depending on the input from a broader audience of BI participants. It would probably be wise to extend a review of the proposed maturity model to a few more BI or healthcare experts.

An organizational BI maturity level assessment tool was chosen as the method of validation to reach a large number of stakeholders within a relatively short amount of time. Other methods of determining maturity levels, such as interviews with stakeholders or review of actual documents, could provide more insight into the actual BI maturity of an organization. Also, because of time constraints for completing a survey, five statements (one for each maturity level) were asked of each of the 12 dimensions. This method may have provided only a glimpse into the maturity level of each dimension. One consideration for future research might be to add more statements, but break the participants into data user and data provider groups. The statements could then be made more applicable to their level of familiarity of each of the process areas.

In addition, a validation of the model usage and BI maturity scoring was demonstrated within one healthcare organization. While the representation of stakeholders crossed a variety of healthcare settings and different stakeholder groups, they all belonged to the same healthcare system. Further research could be done by extending the organizational BI maturity level assessment tool to other healthcare organizations.

Contribution to Research

The creation of a maturity model for business intelligence in healthcare contributes to information and knowledge management in healthcare, provides guidance to BI deployment

initiatives and serves as a readiness assessment to move up each level in maturity. This research made five important contributions to research. First, evaluating the complexities and differences of information management in healthcare provided further understanding of the challenges to the business intelligence environment in healthcare. Second, a gap analysis of existing BI maturity models relative to healthcare complexities helped determine if an existing maturity model could be adapted for healthcare. The BI maturity models that have been used in healthcare to date have not focused on specific processes that are unique or of high importance to healthcare. Third, by performing a thorough literature review on healthcare complexities and information needs as well as an analysis of shortcomings of existing BI maturity models, a list of requirements for a healthcare BI maturity model were developed. Fourth, an actual BI maturity model for healthcare was created following an iterative process of model development. The important processes, dimensions, and maturity level functionality for each dimension were defined. And finally, an evaluation of the model was developed and validated by testing the model through an organizational BI maturity level assessment tool given to several key stakeholders in a healthcare organization. The results provided insight into further maturity model refinement as well as the ability to actually determine a BI maturity level score within the organization based on the processes, dimensions, and maturity level functionality definitions created within the maturity model.

Conclusion

Healthcare is a very complex, knowledge-driven industry. The accumulation of data is quickly outpacing the capacity to use the information to improve the efficiency and quality of healthcare. Business intelligence can help organizations improve efficiency in managing information and providing decision makers with timely and accurate information for making decisions. Business intelligence is growing and changing rapidly. As such, business intelligence is more than just technology. It includes understanding the organizational processes and people skills and resources needed to develop a BI strategy.

Maturity models provide organizations a systematic method for assessing their current maturity level relative to business intelligence. Because there are many complexities in healthcare that may not necessarily be addressed in a general maturity model, the creation of a BI maturity model to specifically address healthcare complexities can be very valuable. A healthcare BI

maturity model can include not only organizational, people, and technology processes, but also some of the processes that address the complexities of information management within the healthcare environment.

The purpose of this dissertation was to expand the use of a BI maturity model to include processes directed towards the complexities within healthcare. The value of understanding the maturity level of business intelligence within an organization is extremely important in strategy development. There is no doubt that information technology can help drive some of the changes needed for healthcare reform. By taking the time to create a BI roadmap through the use of a maturity model, the overall management of information within an organization can be better understood and controlled.

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APPENDICES

APPENDIX A: BI PARTICIPANT PROBLEM REQUIREMENTS QUESTIONNAIRE

Overview of Business Intelligence Maturity Models

Business intelligence (BI) is a broad category of technologies, applications, and processes for gathering, accessing, and analyzing data to make better decisions. Organizations use business intelligence to gain data-driven insights on anything related to business performance. It is used to understand and improve performance and to cut costs and identify new business opportunities. Examples include:

- Tracking financial and clinical performance
- Optimizing processes and operational performance
- Measuring, tracking, and predicting particular types of patient discharges and diagnoses
- Improving patient satisfaction and consumer relationships
- Analyzing risk
- Analyzing strategic value

Organizations can assess their readiness for business intelligence through the use of a maturity model. A business intelligence maturity model is a systematic tool to assess key areas of importance to business intelligence relative to their maturity level within an organization. A sound maturity model provides guidance for determining BI maturity and serves as a readiness assessment to implement a BI strategy within an organization.

Characteristics of Maturity Models

Maturity models all share important characteristics including:

- Maturity concept – "what" is being measured. Often these are people or workforce capability, process maturity, or technology maturity.
- Dimensions – specific capability, process, or technology areas that are considered to be relevant and of interest. Each dimension is then further broken down into sub-processes that include specific practices or activities at each level.

- Levels – the states of maturity or functionality that should be able to be accomplished with each sub-process at each level. The higher levels are intended to be more complex and harder to achieve than the lower levels.
- Maturity principle – the scoring method for the model – either continuous or staged. In a staged model, compliance with all elements of a level must be met before moving on to the next level. Continuous maturity models allowing scoring of activities at different levels.
- Assessment approach – determines how the organization's maturity level will be evaluated, i.e., using a qualitative interview process or a quantitative questionnaire process.

An example of a small part of the Data Warehouse Capability Maturity Model to show characteristics:

Maturity concept: Process Maturity

Dimensions: DW Technical Solution and DW Organization and Processes

Sub-Processes within the DW Technical Solution: Architecture, Data Modeling, ETL, and Business Applications

Levels of functionality with one activity within the Business Applications Sub-Process:

Initial (Level 1)	**Repeatable (Level 2)**	**Defined (Level 3)**	**Managed (Level 4)**	**Optimized (Level 5)**
Static and parameter-driven reports and query applications	Ad-hoc reporting; online analytical processing (OLAP)	Visualization techniques; dashboards and scoreboards	Predictive analytics; data and text mining; alerts	Closed loop BI applications; real-time BI applications

Scoring: Scoring for each key sub-process as well as an overall maturity level scoring.

Assessment approach: Quantitative questionnaire to several key stakeholders within different types of businesses.

BI Participant Problem Requirement Questionnaire

The purpose of this evaluation is to get your feedback on the problem requirements that have been identified for a BI maturity model specific to healthcare. You have been selected to participate in this study because of your knowledge of business intelligence and/or the healthcare domain. We understand that you may not know everything about BI maturity models, but please provide the information with the knowledge you have. All personally identifiable information will be kept confidential and used only as needed for the research.

When completing the questionnaire, please use your knowledge of business intelligence, healthcare and/or background with other maturity models to determine if the problem requirements accurately and completely describe areas of importance for the design of a healthcare-specific BI maturity model. If you have any questions about this questionnaire, please contact Patti Brooks at patti.brooks@avera.org or (605) 995-2502. The anticipated time to complete the questionnaire is five to ten minutes. Please complete this questionnaire as soon as possible and return to patti.brooks@avera.org.

Use the Tab or down arrow key to move from box to box to fill in your answers. Click inside the box to select an answer. Click again inside the box to unselect an answer. In areas where free text comments are asked, use the Tab or down arrow key to get to the boxed area and just start typing your response.

In order to better understand your background with business intelligence and/or healthcare, please complete the demographic information below.

Demographic Information	
Which category best fits your primary job function?	☐ Business intelligence or data analytics ☐ Healthcare consulting ☐ Marketing ☐ Strategic planning ☐ Other (Please specify category of job function)
How many years have you worked <u>in some role</u> with business or clinical intelligence or data analytics?	☐ 0-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16–20 years ☐ > 20 years
How many years have you worked <u>in some role</u> within the healthcare industry?	☐ 0-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16–20 years

	☐ > 20 years

The identified requirements are listed below in italics. The related sub-requirements are directly below each requirement in a bulleted format. In order to determine if the problem requirements/sub-requirements are relevant and complete, please review each requirement on the left and complete your responses on the right using the following rating:

1 = Strongly Disagree 2 = Disagree 3 = Uncertain 4 = Agree 5 = Strongly Agree

Requirement/Sub-requirements	**Questions to Complete for Requirement**
Provide a conceptual structure for managing the use of business intelligence in healthcare. • A maturity model should provide, for each healthcare process, different states of BI infrastructure and process development. • The different states of development should be conceptualized into levels and organized such that organizations can progress from one level to another. • Higher maturity levels should be of greater utility and value than lower levels.	• I feel this requirement is relevant to assess BI maturity in healthcare. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • I feel the sub-requirements support the overall requirement. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • If you have any suggestions for changes to this requirement or sub-requirements, please comment:
Focus on the needs of operational, financial and clinical information. • A healthcare BI maturity model should include process development that addresses the integration of operational, financial, and clinical processes. • Higher maturity leveling within the integrated processes should include predictive analytics.	• I feel this requirement is relevant to assess BI maturity in healthcare. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • I feel the sub-requirements support the overall requirement. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • If you have any suggestions for changes to this requirement or sub-requirements,

	please comment:
Focus on capturing key business and clinical intelligence processes and practices, taking into consideration specific processes within healthcare. • A healthcare BI maturity model should capture key process areas and critical success factors in the development of business and clinical intelligence. • The key process areas in the healthcare model should take into consideration processes that bring additional complexity within healthcare. These include the integration of operational/financial and clinical information and the exchange and interoperability of external data.	• I feel this requirement is relevant to assess BI maturity in healthcare. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ I feel the sub-requirements support the overall requirement. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • If you have any suggestions for changes to this requirement or sub-requirements, please comment:
Incorporate key processes that include people, technology, and organizational processes. • In the healthcare BI maturity model, three broad process areas should include people, technology, and organizational processes. Within these processes, further breakdown of dimensions should include key areas that are important to each process, including vision and BI strategy, knowledge management, staff skill levels, data quality, and technology infrastructure.	• I feel this requirement is relevant to assess BI maturity in healthcare. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • I feel the sub-requirements support the overall requirement. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • If you have any suggestions for changes to this requirement or sub-requirements, please comment:
Incorporate aspects of quality including system quality, information quality, and service quality. • In the maturity model, there should be a process or dimension that addresses data quality. • Functionality in the maturity levels that should be addressed includes data definitions/metadata, data standardization, data governance, and	• I feel this requirement is relevant to assess BI maturity in healthcare. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • I feel the sub-requirements support the overall requirement. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐

data availability.	• If you have any suggestions for changes to this requirement or sub-requirements, please comment:
Provide an understanding of relationships between the different levels and key processes involved in a maturity model by incorporating theoretical underpinnings. • The maturity model processes should imply theory by demonstrating social and technical subsystems. This is done by incorporating key process areas and dimensions which include people, technology, and organizational processes.	• I feel this requirement is relevant to assess BI maturity in healthcare. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • I feel the sub-requirement supports the overall requirement. 1 2 3 4 5 ☐ ☐ ☐ ☐ ☐ • If you have any suggestions for changes to this requirement or sub-requirements, please comment:

If you feel there is anything missing in the requirements list that you are not already commented on, please explain:

Thank you for taking the time to complete this questionnaire. Your expertise and feedback are greatly appreciated and will contribute to the overall quality of this research.

APPENDIX B: ROUND ONE WITH BI PARTICIPANTS – CORE PROCESSES

Evaluation of the General Processes and Sub-Processes Proposed in the Maturity Model

The three broad categories of processes proposed for the healthcare BI maturity model are included in bold print. In an effort to determine a list of key process areas, an analysis was done by reviewing multiple healthcare articles on business intelligence, business analytics, critical success factors, theories behind IT success, and the dimensions summarized in the most common business intelligence maturity models.

The sub-processes, or dimensions, in the maturity model are listed below each process. Because of unique BI information needs for healthcare, two additional sub-processes are being proposed. These include: (1) integration of clinical and financial information in healthcare and (2) external information needs.

Organizational Processes

- Processes focused on vision and BI strategy
- Processes focused on management support and championship
- Processes focused on performance improvement and added value
- Processes focused on the integration of administrative/financial and clinical data
- Processes focused on transforming information to integrated knowledge in workflow

People and Team Processes

- Processes focused on project management and methodology related factors
- Processes focused on change management
- Processes focused on team and individual skill levels/needs
- Process focused on communication management to key stakeholders

Technology Processes

- Processes focused on strategic technology infrastructure
- Processes focused on data quality
- Processes focused on external data needs

1. Do you feel the three processes capture the key components of business intelligence?

   Yes _____ No _____ Maybe _____

   If the answer is No or Maybe, please add comments:____

   Results: The Yes/No/Maybe was not answered by all participants, so comments only will be listed:

   - Third dimension under Organizational Processes would change to read: "Processes focused on process/performance improvement and added value."
   - Fifth dimension under Organizational Processes would change to read: "Processes focused on transforming information to integrated knowledge in workflow and then actionable information."
   - Fourth dimension under People and Team Processes would make sure the fourth process "Processes focused on communication management to key stakeholders" extends into the other processes as well.
   - Second dimension under Technology Processes, would extend the "Processes focused on data quality" to include data governance and include privacy and security, life cycle management, meaningful use/consent, metadata management as well as data quality.
   - Would like to see something about creating a learning organization – what structure exists in organizations – what education, mentoring, leadership coaching to create a learning environment. Probably under People and Team – leadership development.

2. Do you feel the twelve sub-processes (dimensions) adequately capture the breakdown of sub-processes or practices needed for BI in healthcare?

   Yes_____ No_____ Maybe _____

   If the answer is No or Maybe, please add comments:

   Results: The Yes/No/Maybe was not answered by all participants, so comments only will be listed:

   - It seems like something is missing here. I am looking for a healthcare delivery process, but they appear to be included in the other processes. Would suggest creating a separate core process category for healthcare.

- Are the sub-processes of similar size, scope, and relevance? For example, management support and championship make sense but integration of administrative/financial and clinical data seems to be perhaps more tactical than strategic and I am not sure yet the full scope of it. It is a huge task that dwarfs the others similar in size. Same with external data needs.

3. Two additional sub-processes (dimensions) were added for healthcare. They are (a) Processes focused on integration of administrative/financial and clinical data and (b) Processes focused on external data needs. Do you feel these two additions are necessary to include unique challenges of BI in healthcare?

   Yes _____ No _____ Maybe _____

   If the answer is No or Maybe, please add comments:

   Results: The Yes/No/Maybe was not answered by all participants, so comments only will be listed:

   - External data needs/interoperability is important in healthcare, i.e., billing requirements, outside integration – assessment – how much nomenclature we need to clinical, financial, risk management, utilization.
   - I don't feel the addition for external data needs is necessary. Most BI engagements in my experience require some sort of integration with external data sources. An overall BI architecture phase should account for it.

4. Are there any changes you would suggest making?

   Yes_____ No_____ Maybe _____

   If the answer is No or Maybe, please add comments:

   Results: The Yes/No/Maybe was not answered by all participants, so comments only will be listed:

   - Again, I would like to see something added about creating a learning organization.

APPENDIX C: ROUND TWO WITH BI PARTICIPANTS – FIRST REVIEW OF BIMM

Proposed Maturity Model and Functionality at each Maturity Level

The next step is to review known maturity models/levels to determine appropriateness and comprehensiveness. I intend to use the Capability Maturity Model Integrated (CMMI). It is based on the Capability Maturity Model (CMM) developed from the Carnegie Mellon Software Engineering Institute (SEI). The goal of CMMI is to improve the usability of maturity models by integrating different models into one framework. The maturity levels are measured as an aggregate for all processes in an organization. The five levels of CMMI are (1) Initial, (2) Managed, (3) Defined, (4) Quantitatively Managed, and (5) Optimizing. The processes focus on process improvement of overall organizational performance. The five levels of CMMI are defined as follows:

Level 1 – Initial	Processes are usually ad hoc and chaotic. Typically the organization does not provide a stable environment to support processes. Success often depends on the competence and heroics of the people within the organization and not on the use of proven processes. Services can work, but they often exceed the budget and schedule.
Level 2 – Managed	A managed process satisfies Level 1 and has the basic infrastructure needed to support the process. It has enterprise goals as well as process area goals. The processes are consciously planned and executed, employ skilled people, have adequate resources, and involve key stakeholders. A managed process is monitored, controlled, and reviewed.
Level 3 – Defined	A defined process satisfies Level 2 and has the necessary degree of rigor in standards, process descriptions, and procedures to be learnable, repeatable, easily audited, consistent in results and capable of producing identical results given identical circumstances. Processes are characterized for the organization and are proactive with an understanding of the relationships of process activities and detailed measures of the work, work products, and services.
Level 4 – Quantitatively Managed	A quantitatively managed process satisfies Level 3 and is controlled using statistical and other quantitative techniques. Processes have measurable targets of quality and performance and they are used to manage the process. Quality and performance are measured and managed throughout the life of

	the process. Process performance is predictable.
Level 5 – Optimizing	An optimizing process meets all Level 4 criteria and is continuously improved through analyzing and understanding the causes of variation for the process. Processes focus on process improvement of overall organizational performance.

The sub-processes (now called dimensions) now need to have capability functionality defined for each maturity level. Whenever possible, components of the proposed functionality were taken from literature review of other similar processes (dimensions) and levels.

Organizational Processes

Processes focused on vision and BI strategy (OS)	
Description	The objective of this process is to gain a clear understanding of the vision for business intelligence within the organization. Every BI project should clearly justify both the cost and the benefits of solving a business problem (Gangadharan & Swami, 2004). It is important to identify a business strategy and to discover key value drivers required to attain a strategy (Ariyachandra & Frolick, 2008). The BI initiatives must align with the business vision. Consequently, understanding the business vision is critical (Yeoh & Koronios, 2010). BI initiatives often start with an IT focus on the technology, but BI is a business centric concept; there must be a business problem to solve (Yeoh et al., 2008).
Levels of Functionality	
Level 1 – Initial	• There are some, but minimal, BI initiatives going on within the enterprise. • BI responsibilities including data modeling, infrastructure management, data validation, and data standardization are decentralized within the enterprise. • Sponsorship for BI initiatives is decentralized within the enterprise.
Level 2 – Managed	• The BI organization and responsibilities are centralized and focus on governance structure for BI and analytical programs, projects, practices, software, architecture, data validation, and data standardization. • BI has strong influential sponsorship from IT. • There are standardized efforts regarding operations of BI initiatives.
Level 3 – Defined	• BI has sponsorship from both the business units and IT. • There is a BI steering committee within the enterprise composed of membership from management, business

	units, and IT. • An initial BI strategy has been established.
Level 4 – Quantitatively Managed	• BI initiatives are prioritized, in part based on added value to the enterprise. • There is portfolio management for a systematic BI roadmap. • BI initiatives are used to solve business problems.
Level 5 – Optimizing	• There is a comprehensive enterprise BI strategy which focuses on organizational processes as well as technology and tools. • The BI strategy plan is updated on a regular basis.
Processes focused on management support and championship (OMS)	
Description	The objective of this process is to understand the environment of management and support for BI. One of the greatest challenges in BI initiatives has been management and organizational commitment, including attitudes to change, time, cost, technology, and project scope (Yeoh et al., 2008). Committed management support and adequate resources have been found to determine BI implementation success (Watson & Haley, 1997). Without dedicated support from top management, a BI project may not receive appropriate recognition and the support that it needs to be successful (Marciano, 1995).
Levels of Functionality	
Level 1 – Initial	• The BI initiatives and responsibilities within the enterprise are decentralized in a way that each department or facility carries out their own initiatives. • Enterprise BI initiatives have not necessarily been established or communicated to each department or facility.
Level 2 – Managed	• There is defined governance and standards for development of BI initiatives. • There is defined governance and standards for operations of BI initiatives. • There is defined governance and standards for tools and applications of BI initiatives.
Level 3 – Defined	• There is defined governance for the management of standard data elements for BI initiatives. • Management understands the resources needed for BI initiatives, including cost, time, technology, and staff. • BI is used by specialized analysts.
Level 4 – Quantitatively Managed	• There is defined governance and standards for content of data which may mean standardized processes and workflow to obtain consistent data for BI initiatives.

	• Management provides the resources needed for BI initiatives, including cost, time, technology, and staff. • BI is used by middle and upper management.
Level 5 – Optimizing	• BI initiatives are treated as integration necessary for overall strategic business decisions. • BI initiatives are consistently used by management for continuous process improvement efforts within the enterprise.
Processes focused on performance improvement (PI) and added value (OPI)	
Description	The objective of this process is to determine how performance improvement indicators are used to evaluate and improve the overall performance of the healthcare organization. Performance dashboards are popular ways to monitor organizational performance (Eckerson, 2005). More than ever, hospital leaders feel the need to measure, report, and sustain improvements in patient care quality and safety. As information is pushed closer to the point of service, intelligent systems hold the promise for decision-making at all levels (Fitzpatrick, 2006).
Levels of Functionality	
Level 1 – Initial	• Information is primarily obtained from ad-hoc reports. • Information for key performance indicators may be used by different departments, but the definitions of what is included in the information may not necessarily be the same.
Level 2 – Managed	• There are enterprise goals for performance improvement for quality, cost, and patient satisfaction. • Information needed for performance improvement is primary obtained from static reports. • There is a culture of measurement.
Level 3 – Defined	• Standard definitions for key performance indicators for both financial and clinical performance have been created for use throughout the enterprise. • Performance tools are available and used by the front-end user for information needed for performance improvement.
Level 4 – Quantitatively Managed	• Dashboards and key performance indicators for both financial and clinical performance are used throughout the enterprise. • Key performance indicators are used on a regular basis to measure quality, cost, and patient satisfaction.
Level 5 – Optimizing	• There are regular process improvement efforts in place, including cost, quality, and patient satisfaction. • There is a systematic and comprehensive measurement of

	actual BI usage.
Processes focused on transforming integration of information to knowledge in workflow (OK)	
Description	The objective of this process is to determine the degree to which information is transformed to knowledge which can then be permeated throughout the organization. It is important to not only communicate and share information with key stakeholders, but also to transform the information into knowledge. Integration is the process of combining explicit knowledge into new patterns and relations. The explicit knowledge is understood by testing and validating the relationships, which can then be converted into new tacit knowledge (Herschel & Jones, 2005)
Levels of Functionality	
Level 1 – Initial	• The data and reports from BI initiatives produce useful information. • The reports produce information in question.
Level 2 – Managed	• There are enterprise goals for the sharing of information from BI initiatives. • New information gained from BI initiatives is reviewed and shared with key stakeholders on a regular basis (socialization stage of knowledge management).
Level 3 – Defined	• The information gained from BI initiatives is shared in a consistent, standard way. • All key stakeholders have a common understanding of the information. • Knowledge that is based on experience but not necessarily documented (tacit knowledge) is documented, such as in policy and procedure format (explicit knowledge) so that processes can be learned and repeated. • There is a common standard for what information needs to be documented and communicated.
Level 4 – Quantitatively Managed	• The new information gained from BI initiatives is reviewed regularly using quantitative tools to evaluate for new patterns and relationships (data mining). • The new information gained from BI initiatives is helpful in establishing the need for performance improvement in certain areas or departments. • Quantitative techniques are used to review new patterns of information created by explicit knowledge, such as in the healthcare domain, the analysis of documented clinical results of a patient or groups of patients. • New patterns of information are used in performance

	improvement activities.
Level 5 – Optimizing	• The new information gained from BI initiatives has become common knowledge. • The new knowledge gained is now part of the process improvement activities across the enterprise. • The new information developed from reviewing information for performance improvement is converted into a new level of knowledge and understanding which permeates regular decisions made throughout the enterprise.

People and Team Processes

Processes focused on project management and methodology related factors (PPM)	The objective of this process is to determine the degree to which a project management process is followed throughout the establishment of BI projects. BI projects are typically different from transactional application projects. The project team must design a robust and maintainable architecture that can accommodate the needs in an emerging and changing environment. This requires highly competent team members. The BI team should be cross-functional and composed of both technical and business personnel (Yeoh & Koronios, 2010).
Description	
Levels of Functionality	
Level 1 – Initial	• Project management goals have not been fully developed. • Project management goals have been developed, but are not necessarily tied to enterprise goals.
Level 2 – Managed	• Project management goals have been developed and are tied to enterprise goals. • In general, there is an appropriate mix of skilled people (IT and business users) on project teams. • Key stakeholders are involved in the BI project.
Level 3 – Defined	• Project standards, processes, and procedures are followed on a consistent basis. • Project results appear to be consistent.
Level 4 – Quantitatively Managed	• Projects are monitored using quantitative tools for processes such as time, cost, and scope. • Specific project targets have been established for quality and performance. • The project targets are managed with quantitative tools.
Level 5 – Optimizing	• Projects are continually being evaluated for improvement (i.e., lessons learned). • Projects are evaluated by analyzing causes and variations in processes or projects.
Processes focused on change management	

(PCM)	
Description	The objective of this process is to determine how change management is handled across the organization. Appropriate scope and planning facilitate flexibility and adaptability to requirements for change, especially within the timeframe identified and the resources available. An adequate scope helps the project team focus on the crucial milestones (Yeoh & Koronios, 2010). In addition, it has been noted that better user participation in the change process can lead to better communication of the users' needs, which can help ensure a successful BI implementation (Yeoh & Koronios, 2010).
Levels of Functionality	
Level 1 – Initial	• When changes are implemented, there is not necessarily a strong connection between the change and the overall goals of the enterprise. • Changes made often exceed the budget and schedule.
Level 2 – Managed	• Changes that are implemented match the goals of the enterprise. • The amount of change within the enterprise is taken into consideration when change management processes are put into place. • Change management processes are monitored and controlled.
Level 3 – Defined	• Change management processes are standardized and consistently managed across the enterprise. • Change is proactive within an enterprise.
Level 4 – Quantitatively Managed	• Targets for quality and performance changes are established and managed. • The results of change are monitored with quantitative tools to determine the impact on the enterprise.
Level 5 – Optimizing	• There is a culture of continuous improvement throughout the enterprise. • The culture of change is supported by management throughout the enterprise.
Processes focused on a learning environment (PLE)	
Description	
Level 1 – Initial	• There is some, but minimal, understanding of data and how the data can be used within the organization.
Level 2 – Managed	• There is a process in place to train leadership and staff about the data and how to use the information. • There are skilled employees in place to manage, train, and creating a learning environment about information management.

Level 3 – Defined	• Leadership and staff are trained on how to use the data and information and there is a common understanding of results among staff.
Level 4 – Quantitatively Managed	• The data is analyzed using statistical and other quantitative techniques. • Processes have measurable targets of quality and performance.
Level 5 – Optimizing	• Because of the information and knowledge gained, continuous process improvement is a part of the culture of the organization.
Processes focused on team and individual skill levels/needs (PSK)	
Description	The objective of this process is to evaluate if the BI teams have a focus on team and individual skill levels and needs. BI initiatives often span many departments and demand extensive data and resources from the business units (Yeoh & Koronios, 2010). Organizations tend to rely on their IT staff to be responsible for most system implementation projects. However, BI projects are different from transactional applications and require much more of a team approach (Fuchs, 2006; Turban, Sharda, Aronson, & King, 2007). In addition, appropriate training not only for team members but also users of the data is very important.
Levels of Functionality	
Level 1 – Initial	• Appropriate skill levels and training relative to BI have been identified for IT staff and business users. • Training and skill levels for BI do not necessarily tie with the needs of the overall enterprise.
Level 2 – Managed	• Training and skill levels for BI initiatives have been defined for both IT staff and business users and match the needs of the overall enterprise goals. • Adequate training and education for BI is monitored and controlled.
Level 3 – Defined	• The enterprise proactively determines the appropriate skill levels needed for BI initiatives. • Targets of appropriate skill levels for BI for both IT staff and business users/managers are established and managed.
Level 4 – Quantitatively Managed	• Staff that use quantitative tools have an adequate level of skill to manage the tools. • There is a process for evaluation and oversight of the use of quantitative analysis to make decisions. • The business users and management staff are adequately trained to use the quantitative tools needed to use and understand BI reports and dashboards.
Level 5 – Optimizing	• There is a culture of continuous improvement with ongoing

	training and education on BI analysis and use. • There is a culture of continuous learning of new ways BI/analytics can support and move the enterprise forward.
Processes focused on communication management to key stakeholders (PCMM)	
Description	The objective of this process is to develop an understanding of the communication process among key stakeholders in the organization. As with any type of project, good communication management to the key stakeholders, administrative teams, and the business users is an essential ingredient for the success of the project or initiative (Schwalbe, 2006).
Levels of Functionality	
Level 1 – Initial	• Communication of BI initiatives is not necessarily tied to the enterprise goals. • There is no formal communication management plan across the enterprise for BI initiatives.
Level 2 – Managed	• There is communication of the BI initiatives which matches enterprise goals. • The communication of BI initiatives is monitored and controlled.
Level 3 – Defined	• There is a standard communication plan for BI initiatives across the enterprise. • The communication management plan for BI initiatives includes who needs the information, when it is needed, and how it will be received.
Level 4 – Quantitatively Managed	• Communication and reports to key stakeholders are given on a regular basis using statistical and other quantitative techniques. • The communication process about BI initiatives is predictable.
Level 5 – Optimizing	• There is a culture of continuous improvement in communication and information sharing of BI results. • Ongoing sharing of information from BI initiatives to key stakeholders is apparent.

Technology Processes

Processes focused on strategic technology infrastructure (TI)	
Description	The objective of this process is to develop an understanding of the technology infrastructure. Data in healthcare comes in many forms. Some of the information in the electronic health record is structured data. There is also unstructured free text information,

	digital images such as the Picture Archiving Systems (PACs) radiology images, and wave forms from other medical devices, such as electrocardiograms and fetal monitoring systems (Mettler & Vimarlund, 2009). One of the key critical success factors that has been identified is that the technical framework of a BI system must be scalable and flexible in order to meet the dynamic business needs (Olszak & Ziemba, 2007). Therefore, it is important to develop a scalable system framework that can allow additional data sources, attributes, and dimensional areas. The infrastructure also needs to accommodate external data sources. In the healthcare environment, this could mean information from patients, federal agencies, insurance companies, and other healthcare institutions (Mettler & Vimarlund, 2009; Yeoh & Koronios, 2010). In an effort to help business users navigate and manipulate the data model, the structure and model of the data warehouse must be related to the business users' perception of the business objectives and processes.
Levels of Functionality	
Level 1 – Initial	• Data is retrieved is out of individual departmental systems. • The format and definitions of data are inconsistent across information systems and departments.
Level 2 – Managed	• There are some efforts to standardize data. • A data architecture strategy is in place to include the growing needs and types of information in a healthcare environment. • The role of IT is operator of the infrastructure and provider of standardized services.
Level 3 – Defined	• There are standardized definitions for data that are used in BI initiatives across the enterprise. • A data warehouse is in place with integrated data and one version of the truth (i.e., the data warehouse contains the standard master data on a patient across all information systems in the enterprise). • A BI strategy addresses the technical infrastructure requirements. • The role of IT is a business partner working with business users.
Level 4 – Quantitatively Managed	• The ability to retrieve and use the data is flexible and is available to the business users. • Predictive analytics, data mining, and data visualization tools (such as dashboards) are used on a regular basis.
Level 5 – Optimizing	• Information is readily available to the end user and key stakeholders. • Information is used on a regular basis for continuous process improvement at all levels of the enterprise.

Processes focused on data quality (TDQ)	
Description	The objective of this process is to develop an understanding for the quality of data and maturity of the organization with respect to data governance. Poor quality data can have substantial social and economical impacts (Wang & Strong, 1996). Because healthcare organizations are increasingly under pressure to hold costs down, good cost, charge, and payment data is essential to keeping the costs down and remaining competitive. In addition, the integration of clinical and financial data is costly, time consuming, and often causes issues with data quality (Leitheiser, 2001). The integrity of information is a key concern and challenge. Problems in data accuracy and validity can impair the value of the information that healthcare is investing (Kloss, 2012).
Levels of Functionality	
Level 1 – Initial	• Data definitions are either non-existent or are developed within departments. • Data is inconsistent and cannot be trusted. • There is no formal method for data governance.
Level 2 – Managed	• There are some efforts in data standardization, but they are not consistent across the enterprise. • Data is structured in a way to specifically address individual needs for reporting. • The enterprise has recognized the importance of standards. • Skilled people have been put into place to manage the quality of the data.
Level 3 – Defined	• Data needed for BI initiatives is standardized and enforced across the enterprise. • There is a data governance council in place consisting of members from IT and the business user community. • Processes which drive the standardization of data are in place and enforced across the enterprise. • Strategic information is trustworthy and used for strategic decision making.
Level 4 – Quantitatively Managed	• Quantitative tools are used to analyze and display information. • Measurable targets for quality and performance are in place using quality data.
Level 5 – Optimizing	• Information is used on a regular basis for continuous quality and process improvement. • Quality data is used to analyze and understand the causes of variation in a process.

Healthcare Processes

Processes focused on	

administrative/financial data (HAF)	
Description	
Levels of Functionality	
Level 1 – Initial	• There is some, but minimal, integration of administrative/financial data among departmental applications within the enterprise. • Administrative/financial data across applications is inconsistent. • There is not a conscious rollout strategy to integrate administrative and financial data across different department applications when purchasing information systems.
Level 2 – Managed	• There are enterprise goals to evaluate administrative and financial systems for the integration of applications. • There are adequate staffing levels in place to implement and support the administrative and financial applications.
Level 3 – Defined	• There are defined data definition standards to allow for easy integration of administrative and financial applications across various systems. • Consistent results are obtained from the reported information because of the integration of administrative and financial systems.
Level 4 – Quantitatively Managed	• Performance improvement activities include the use of key performance indicators (KPIs) established for administrative/financial data. • Administrative/financial information is used for predictive analytics.
Level 5 – Optimizing	• Process improvement activities include administrative/financial data used on a regular basis to make decisions.
Processes focused on clinical data (HC)	
Description	
Levels of Functionality	
Level 1 – Initial	• There is some, but minimal, integration of clinical data among the various clinical applications within the enterprise. • Clinical data across applications is inconsistent or non-existent causing redundancies in collecting data. • There is not a conscious rollout strategy to integrate clinical data across other clinical applications when purchasing information systems.
Level 2 – Managed	• There are enterprise goals to evaluate clinical systems for the integration of applications.

	• There are adequate staffing levels in place to implement and support the clinical applications.
Level 3 – Defined	• There are defined data definition standards to allow for easy integration of clinical applications across various clinical systems. • Consistent results are obtained from the reported information because of the integration of clinical systems.
Level 4 – Quantitatively Managed	• Performance improvement activities include the use of key performance indicators (KPIs) established for clinical data. • Clinical information is used for predictive analytics.
Level 5 – Optimizing	• Process improvement activities include clinical information used on a regular basis to make decisions. • On a regular basis, clinical information is available at the point of care, often evidence-based, to make decisions.
Processes focused on the integration of administrative/financial and clinical data (HI)	
Description	The objective of this process is to determine the level of integration of administrative/financial and clinical data. Despite many efforts to implement electronic health records, clinical and financial data are still often segregated in separate silos in proprietary systems with incompatible formats(Fayyad, 2002; Hersh, 2004). Clinical intelligence combines business intelligence with clinical data (Hagland, 2011). It is important for healthcare scorecards and performance improvement efforts to include information to improve quality and profitability (Rohloff, 2011).
Levels of Functionality	
Level 1 – Initial	• There is some, but minimal, integration of administrative, financial, and clinical information. • There is not a conscious rollout strategy to integrate administrative, financial, and clinical information when purchasing information systems.
Level 2 – Managed	• There is a mechanism in place to evaluate and plan for the integration of core administrative, financial, and clinical data. • There are adequate staffing levels in place to interface and support the core administrative, financial, and clinical systems. • Skilled people are in place to interface the information.
Level 3 – Defined	• There are defined data definition standards to allow for easy integration of administrative, financial, and clinical systems. • Consistent results are obtained from the reported information because of the integration of systems.

Level 4 – Quantitatively Managed	• Performance improvement activities include integrated information from administrative, financial, and clinical data. • Integrated administrative, financial, and clinical information is used for predictive analytics.
Level 5 – Optimizing	• Process improvement activities include administrative, financial, and clinical information that is used together to make decisions. • On a regular basis, information to make decisions (clinical with administrative/financial integration) is available at the point of care, often evidence-based.
Processes focused on external data needs/interoperability (HED)	
Description	Accountable care will require treating individuals across the continuum of care. It changes healthcare delivery practices by shifting the way we practice medical care. The goal will be to keep patients/consumers healthy and customize care for patients rather than treat each one the same (Glaser, 2012). In addition, there is a growing need to connect with payers and regulating agencies as well as patients and to integrate information from outside information systems into the core electronic health records in the healthcare facilities. One of the ultimate capabilities to pull together information on the total patient experience across the continuum is predictive modeling (Spooner, 2012).
Levels of Functionality	
Level 1 – Initial	• There are inconsistent data definitions between internal and external data. • Interpretation and use of external data is difficult because of lack of data standards.
Level 2 – Managed	• There are some efforts in standard data definitions between internal and external data. • There is a process in place to monitor, control, and review the internal versus external data.
Level 3 – Defined	• Standard data definitions are used on a regular basis for both internal and external data. • The regular use of industry standards for nomenclature and classification systems is used.
Level 4 – Quantitatively Managed	• Predictive modeling includes both internal and external data. • Process improvement is utilized with information from external data sources.
Level 5 – Optimizing	• External data is integrated into internal data systems. • External data is used on a regular basis for continuous

	quality improvement of internal processes across the enterprise.

APPENDIX D: ROUND THREE WITH BI PARTICIPANTS – SECOND REVIEW OF BIMM

The highlighted areas were the changes suggested from Round Two of the review.

Level Definitions:

Level 1 – Initial	Processes are usually ad hoc and chaotic. Typically the organization does not provide a stable environment to support processes. Success often depends on the competence and heroics of the people within the organization and not on the use of proven processes. Services can work, but they often exceed the budget and schedule.
Level 2 – Managed	A managed process satisfies Level 1 and has the basic infrastructure needed to support the process. It has enterprise goals as well as process area goals. The processes are consciously planned and executed, employ skilled people, have adequate resources, and involve key stakeholders. A managed process is monitored, controlled, and reviewed.
Level 3 – Defined	A defined process satisfies Level 2 and has the necessary degree of rigor in standards, process descriptions, and procedures to be learnable, repeatable, easily audited, consistent in results and capable of producing identical results given identical circumstances. Processes are characterized for the organization and are proactive with an understanding of the relationships of process activities and detailed measures of the work, work products, and services.
Level 4 – Quantitatively Managed	A quantitatively managed process satisfies Level 3 and is controlled using statistical and other quantitative techniques. Processes have measurable targets of quality and performance and they are used to manage the process. Quality and performance are measured and managed throughout the life of the process. Process performance is predictable.
Level 5 – Optimizing	An optimizing process meets all Level 4 criteria and is continuously improved through analyzing and understanding the causes of variation for the process. Processes focus on process improvement of overall organizational performance.

Framework Including Processes/Functionalities at Maturity Levels 1-5

Organizational Processes	Level 1: Initial	Level 2: Managed	Level 3: Defined	Level 4: Quantitatively Managed	Level 5: Optimizing
Processes focused on vision and strategy	• BI efforts are static, have a limited lifespan or value, and may or may not be part of critical clinical or business processes. • BI responsibilities may include infrastructure management, data validation, data standardization and are non-existent, inconsistent, or decentralized within the	• The BI organization and responsibilities are managed and defined for specific projects, and may inconsistently focus on governance structure for some components including BI analytical programs, projects, practices, software architecture,	• The BI organization and responsibilities are managed and defined by a central committee and governance, and focus on governance structure for BI and analytical programs, projects, practices, software, architecture, data validation, and data standardization. • Comprehensive BI strategy,	• BI initiatives are prioritized, in part, based on added value to the enterprise • BI initiatives are measured using statistical and quantitative techniques.	• There is a comprehensive enterprise BI strategy which focuses on organizational processes and drives the needed supporting infrastructure, technology, and tools. • The BI strategy plan is updated on an ongoing basis, and is a dynamic and responsive part of the culture.

	• enterprise. • Sponsorship for BI initiatives is non-existent, inconsistent, or decentralized within the enterprise.	data validation, and data standardization. • BI has sponsorship from either IT or the business side, but not necessarily both and not necessarily coordinated.	broken into tactical goals and projects, ties directly to and is justified by organizational strategies.		
Processes focused on management support and championship	• The BI initiatives and responsibilities within the enterprise are decentralized in a way that each department or facility typically carries their own initiatives. • Enterprise BI initiatives have not necessarily been established or communicated to each department or facility.	• There are defined standards for development and operations of BI initiatives. • Management understands the resources needed for BI initiatives, including various costs, efforts related to time and materials, technology infrastructure, as well as both technical and clinical staff expertise, skills, and training.	• There is defined organization wide governance for the management of standards associated with clinical and business intelligence, including data quality, data elements, data normalization, data origination, data stewardship, and data chain of control. • Management provides the resources needed for BI initiatives, including cost, time, technology, technology, and staff.	• BI is used across all areas of the organization but may not be leveraged consistently through the chain of command. • Measurement and performance tracking and reporting are appreciated in parts of the organization. • BI is an integral part of the approach for addressing strategic business decisions.	• BI initiatives are consistently used by management and others for continuous process improvement efforts within the enterprise. • Business intelligence (BI) and clinical intelligence (CI) are consistently used and are a critical part of organizational clinical and business processes, used organization wide and from the top to the bottom of the chain of command.
Processes focused on a learning environment and transforming information into knowledge	• There is some, but minimal, understanding of data and how the data can be used within the organization. • There is not a complete inventory of data or reporting. • The data and reports may or may not produce useful information. • Budgeting and work process changes are based on	• There is a process in place to train staff about data and how to begin to use it as information. • There are goals for the sharing of information from BI initiatives. • There is an inventory of reports and data sources that span across the enterprise.	• Executive leadership and a variety of staff are trained on how to access and use data and information. • There is a common understanding of metadata and data analytics approaches among staff. • The information gained from BI initiatives is managed and shared in a consistent, standard way.	• Data is collected and analyzed using standard, documented statistical and other quantitative techniques. • New information gained from BI initiatives is managed centrally, incorporated into metadata, and reviewed regularly using	• The new information gained from BI initiatives has become common knowledge. • Knowledge discovery and utilization is dynamic and active across the enterprise. • There is a culture of continuous improvement and information sharing of BI results. • New knowledge

	intuitive, subjective data. • Communication of BI initiatives is haphazard and inconsistent.	However, the metadata may be inconsistently and not readily available. • There is communication of the BI initiatives and communication is aligned with enterprise standards.	• Knowledge that is based on experience is documented. • There is a common standard for what information needs to be documented and communicated.	quantitative tools to evaluate for new patterns and relationships (data mining). • Communication and reports to all appropriate staff and key stakeholders are given on a regular basis using statistical and other quantitative techniques. Reports demonstrate an organizational understanding and use of BI.	gained is part of process improvement activities across the enterprise and is used to make regular decisions throughout the enterprise.
People and Team Processes	**Level 1: Initial**	**Level 2: Managed**	**Level 3: Defined**	**Level 4: Quantitatively Managed**	**Level 5: Optimizing**
Processes focused on project management and methodology related factors	• Project management standards have not been fully developed or are not necessarily tied to enterprise goals. • Project management is not consistently applied throughout the organization.	• Project management standards and expectations have been developed and are tied to enterprise goals. • In general, there is an appropriate mix of skilled people (IT and business users) on project teams. • Key stakeholders are involved in the BI projects.	• Project management standards, processes, and procedures are followed on a consistent basis. • Project results are reliable and outcomes are generally predictable and as expected.	• Projects are monitored using quantitative tools for processes such as time, cost, and scope. • Project Management Institute (PMI) standards are generally used to design and manage projects as appropriate for their scope and impact. • Project status reporting is shared up and down the chain of command across the enterprise as appropriate. • Specific targets have been established for	• The project management approach, staffing, management, and design are continually being evaluated for improvement (i.e., lessons learned). • Projects are evaluated after completion by comparing initial estimations and goals against final results, including processes, planning, management, deliverables, reporting, and other collateral.

				• quality and performance. • The project targets are managed with quantitative tools.	
Processes focused on change management	• When changes are implemented, there is not necessarily a strong connection between the change and the overall goals of the enterprise. • The change impact on budget, schedule, staffing, and other factors is often not known or estimated. • Change is resisted and can be avoided without consequence. • Changes frequently produce unintended, and detrimental, consequences.	• There are enterprise standards for critical processes; departments migrate to and coordinate their processes to support the standard. • Change management is often reactive. • Change management initiatives are monitored and controlled.	• Change management initiatives are standardized and consistently managed across the enterprise. • The quantity, quality, frequency, and impact of organizational wide change is estimated, managed, and controlled across the enterprise. • Change is more often proactive than reactive within an enterprise. • There is regular and frequent communication to key stakeholders regarding change.	• Targets for quality and performance are established and managed, resulting in change initiatives to meet goals that are managed, analyzed, and coordinated. • The results of change are monitored with quantitative tools to determine the impact on the enterprise. • Systematic evaluation of changes is undertaken.	• There is a culture of continuous improvement throughout the enterprise. • Change is embraced, organized, and easy to affect; it cannot be avoided or misaligned with organization goals without management's knowledge. • The culture of change is supported by management throughout the enterprise.
Processes focused on team and individual skill levels/needs	• Training and skill levels for BI do not necessarily tie with the needs of the overall enterprise.	• Training, skill, education, and applications for BI initiatives have been established, and are monitored and controlled for both IT staff and business users. • There are skilled employees in place to manage, train, and be responsible for creating a learning environment about	• The training, skills, education, and applications for BI initiatives that have been defined are aligned with organizational strategic goals.	• Staff that use quantitative tools have an adequate level of skill to manage the tools. • There are processes for evaluation and oversight of quantitative analysis. • The business users and management staff are adequately trained to use the quantitative tools needed to use and understand BI	• There is a culture of continuous improvement with ongoing training and education related to BI analysis and use. • There is a culture of continuous learning with an evolution and maturation of ways BI and analytics can support and move the enterprise forward. • The enterprise proactively determines the

		information management.		reports and dashboards. • Management staff develop many of the reports and dashboards required for their department's initiatives.	appropriate skill levels needed for new BI initiatives, and re-evaluates needs for existing processes and initiatives.
Technology Processes	**Level 1: Initial**	**Level 2: Managed**	**Level 3: Defined**		**Level 5: Optimizing**
Processes focused on strategic technology infrastructure	• Data is retrieved out of individual departmental systems. • The format of data is inconsistent across information systems and departments. • Information is primarily obtained from static reports or non-electronic sources (i.e., paper charts, calendars, intake sheets)	• A data architecture strategy is in place to include growing needs and types of information in a healthcare environment. • The role of IT is operator of the infrastructure and provider of standardized IT related services. • Static reports are the typical source for information.	• A data warehouse is in place with integrated data. • A BI strategy addresses the technical infrastructure requirements. • The role of IT is a business partner working with business users. • Performance tools are available and used by the front-end user for information needed for PI.	• The data warehouse has "one version of the truth" (i.e., the data warehouse contains the standard master data on a patient across all information systems in the enterprise.) • The ability to retrieve and use the data is flexible and available to the business users. • Predictive analytics, data mining, and data visualization tools (such as dashboards) are used on a regular basis.	• Information is readily available to the end user and key stakeholders. • Information is used on a regular basis for continuous process improvement at all levels of the enterprise. • Dynamic and real-time reporting is available for all appropriate organizational metrics. The organization has a coordinated and organized approach for dynamic reporting on all key organizational metrics, performance in an on-demand manner that occurs with regular frequency with both a short term and long term view.
Processes focused on data quality	• The definitions of data are inconsistent across information systems and departments. • There is no formal method for data	• There are some efforts to standardize data, but they are not consistent across the enterprise. • Data is structured in a	• There are standardized definitions for data that are used in BI initiatives across the enterprise. • Metadata is regularly referenced and	• Quantitative tools are used to analyze and display information. • Measurable targets for quality and performance are in place	• Metadata is managed as a corporate asset and responsibility. • Information is used on a regular basis for continuous quality and

	governance. • Various reports showing similar or related data that should be consistent are not or vary inconsistently.	way to specifically address individual needs for reporting. • The enterprise has recognized the importance of standards. • Skilled people have been put into place to manage the quality of the data.	seen as the key for defining data fields in all systems. • There is an enterprise standard for metadata that is published and referenced consistently. • There is a data governance council in place consisting of members from IT and the business user community.	using quality data. • Reporting is typically on a long term view (weekly, monthly, quarterly, or longer). Some reporting may be on a short term view. • There is limited real-time reporting.	process improvement. • Quality data is used to analyze and understand the causes of variation in a process. • Strategic information is trustworthy and used for strategic decision making.
Healthcare Processes	**Level 1: Initial**	**Level 2: Managed**	**Level 3: Defined**	**Level 4: Quantitatively Managed**	**Level 5: Optimizing**
Processes focused on administrative (operational and financial) data	• There is some, but minimal, integration of administrative data among departmental applications within the enterprise. • Administrative data across applications is inconsistent. • There is not a conscious rollout strategy to integrate administrative data across different departmental applications when purchasing IT systems.	• There are enterprise goals to evaluate administrative systems, such as operational and financial systems, for the integration of applications. • There are adequate staffing levels in place to implement and support the administrative applications.	• There are defined data definition standards to allow for easy integration of administrative applications across various systems. • Administrative systems conform and communicate effectively. • Consistent results are obtained from the reported information because of integration of the administrative systems.	• Performance improvement activities often include the use of key performance indicators (KPIs) which include critical administrative data. • Administrative information is used for predictive analytics.	• Process improvement activities are driven by administrative data. • Administrative data is continuously used to manage and improve the organization, and to track both past and future performance in a dynamic way.
Processes focused on clinical data	• There is some, but sporadic or minimal, integration of clinical data among the various clinical applications within the enterprise. • Clinical data across applications is inconsistent or	• There are enterprise goals to evaluate clinical systems for the integration of applications. • There are adequate staffing levels in place to implement and	• There are defined data definition standards to allow for easy integration of clinical applications across various clinical systems. • New applications and systems always have data	• Performance improvement activities include the use of key performance indicators (KPIs) which include clinical data. • Clinical information is used for predictive	• On a regular basis, clinical information is available at the point of care, often evidence-based, in support of making clinical decisions. • Process improvement activities include clinical

	non-existent, causing redundancies in collecting data. • There is not a conscious rollout strategy to integrate clinical data across other clinical applications when purchasing information systems.	support the clinical applications.	standards and integration addressed as part of the implementation, education, and rollout process. • Consistent results are obtained from the reported information because of the integration of clinical systems. • The organization pursues evidence-based medicine tools to support clinical decision making.	analytics. • Physician dashboards are in use to identify targets of opportunities for clinical improvement initiatives. • Provider decision support is used to help with complex treatment decisions. • The organization implements evidence-based medicine tools.	information used on a regular basis to make decisions.
Processes focused on the integration of administrative and clinical data	• There is some, but minimal, integration of administrative and clinical information. • There is not a conscious rollout strategy to integrate administrative and clinical information when purchasing information systems.	• There is a mechanism in place to evaluate and plan for the integration of core administrative and clinical data. • There are adequate staffing levels in place to interface and support the core administrative and clinical systems. • Skilled people are in place to interface the variety of types of information. • Administrative and clinical data is managed and coordinated by an organizational entity.	• There are defined data definition standards (metadata) to allow for easy integration of administrative and clinical systems. • New applications and systems always have data standards and integration addressed as part of the implementation, education, and rollout process.	• Performance improvement activities include integrated information from administrative and clinical data. • Integrated administrative and clinical information is used for predictive analytics.	• Process improvement activities include administrative and clinical information that is used together to make decisions. • On a regular basis, information to make decisions (clinical with integrated administrative integration) is available at the point of care, often evidence-based. • The variances between data sources and systems and types of data are isolated due to management and coordination of data.
Processes focused on the exchange and	• There are inconsistent data definitions	• There are some efforts in standard data	• Standard data definitions (metadata) are	• Statistical and quantitative tools are used	• External data is fully integrated into internal data

interoperability of external data	between internal and external data. • Interpretation and use of external data is difficult because of the lack of data standards.	definitions between internal and external data. • There is a process in place to monitor, control, and review the internal versus external data. • The organization is reviewing options for participating in regional data exchanges.	defined and used on a regular basis for both internal and external data. • The regular use of industry standards for nomenclature and classification systems is used. • The organization provides leadership in the development and management of regional data exchanges.	to manage internal and external data for performance improvement activities. • Predictive modeling includes both internal and external data.	systems. • External data is used on a regular basis for continuous quality and process improvement of internal processes across the enterprise.

APPENDIX E: ROUND FOUR WITH BI PARTICIPANTS – THIRD REVIEW OF BIMM

Level Definitions Related to BI Processes:

Level 1 – Initial	Processes are usually ad hoc and chaotic. Typically the organization does not provide a stable environment to support processes. Success often depends on the competence and heroics of the people within the organization and not on the use of proven processes. Services can work, but they often exceed the budget and schedule.
Level 2 – Managed	A managed process satisfies Level 1 and has the basic infrastructure needed to support the process. It has enterprise goals as well as process area goals. The processes are consciously planned and executed, employ skilled people, have adequate resources, and involve key stakeholders. A managed process is monitored, controlled, and reviewed.
Level 3 – Defined	A defined process satisfies Level 2 and has the necessary degree of rigor in standards, process descriptions, and procedures to be learnable, repeatable, easily audited, consistent in results and capable of producing identical results given identical circumstances. Processes are characterized for the organization and are proactive with an understanding of the relationships of process activities and detailed measures of the work, work products, and services.
Level 4 – Quantitatively Managed	A quantitatively managed process satisfies Level 3 and is controlled using statistical and other quantitative techniques. Processes have measurable targets of quality and performance and they are used to manage the process. Quality and performance are measured and managed throughout the life of the process. Process performance is predictable.
Level 5 – Optimizing	An optimizing process meets all Level 4 criteria and is continuously improved through analyzing and understanding the causes of variation for the process. Processes focus on process improvement of overall organizational performance.

Framework Including Processes/Functionalities at Maturity Levels 1-5

Organizational Processes	Characteristic	Level 1: Initial	Level 2: Managed	Level 3: Defined	Level 4: Quantitatively Managed	Level 5: Optimizing
Processes focused on vision, strategy, and management support	**BI Vision and Strategy**	• BI initiatives and responsibilities are inconsistent or decentralized and may not tie directly to the vision and strategy of the organization.	• There may be some BI initiatives in process, but they have not necessarily been communicated to each department or facility.	• Comprehensive BI strategy, broken into tactical goals and projects, ties directly to and is justified by organizational strategies. • There are defined standards for development and operations of BI initiatives.	• BI initiatives are prioritized, in part, based on added value to the enterprise. This drives the needed supporting infrastructure, technology, and tools. • BI is an integral part of the approach for addressing strategic business decisions.	• There is a comprehensive enterprise BI strategy which focuses on continuous process improvement and is strongly aligned with the organization's vision and mission. • The BI strategy plan is updated on an ongoing basis, and is a dynamic and responsive part of the culture.

	Sponsorship	• Sponsorship for BI initiatives is non-existent, inconsistent, or decentralized within the enterprise.	• BI sponsorship is typically managed by an area or business purpose but may not necessarily be coordinated across the enterprise.	• There is a standardized process to determine BI sponsorship across the enterprise.	• Business sponsors use quantitative data to manage quality and performance on a regular basis.	• Sponsorship is an integral part of BI project conception and prioritization. Senior leaders acknowledge and expect to be the sponsors of key strategic BI efforts.
	Management Support	• Management does not necessarily understand the value of BI or does not support BI efforts in a way that they are embedded as a critical component of clinical or business processes.	• Management understands the resources needed for BI initiatives, including various costs, efforts related to time and materials, technology infrastructure, as well as both technical and clinical staff expertise, skills, and training.	• Management provides the resources needed for BI initiatives, including cost, time, technology, and staff • Management supports the need for a data governance council to oversee the information management functions of BI. • There is a formal mentorship and training plan for the management team related to the BI program.	• Management supports the measurement, tracking, and reporting of BI initiatives across all areas of the organization.	• BI and clinical intelligence (CI) initiatives are consistently used for continuous process improvement for clinical and business processes and are used organization wide and from the top to the bottom of the chain of command by management. • BI goals are used to reward or incentivize BI leaders and various stakeholders.
Processes focused on creating a "learning organization" and transforming information into knowledge (intelligence)	**Learning Organization**	• There is some, but minimal, understanding of data and how the data can be used within the organization. • There is not a complete inventory of data or reporting. • Communication of BI initiatives is haphazard and inconsistent.	• There is a process in place to train staff about data and how to begin to use it as information. • There are goals for the sharing of information from BI initiatives. • There is communication of the BI initiatives and it is aligned with enterprise communication standards.	• Executive leadership and a variety of staff are trained on how to access and use data and information. • There is a common understanding of metadata and data analytics approaches among staff. • There is a common standard for what information needs to be documented and communicated.	• Data is collected and analyzed using standard, documented statistical and other quantitative techniques. • Communication and reports to all appropriate staff and key stakeholders are given on a regular basis leveraging statistical and other quantitative techniques.	• Information is used on a regular basis for continuous quality and process improvement. • There is a culture of continuous learning with an evolution and maturation of ways BI and analytics can support and move the enterprise forward.

	Information to Knowledge	• The data and reports may or may not produce useful information. • Budgeting and work process changes are based on intuitive, subjective data.	• There is an inventory of reports and data sources that span across the enterprise. However, the metadata may be inconsistent and not readily available.	• The information gained from BI initiatives is managed and shared in a consistent, standard way. • Knowledge that is based on experience is documented.	• New information gained from BI initiatives is managed centrally, incorporated into metadata, and reviewed regularly using quantitative tools to evaluate for new patterns and relationships (data mining). • Reports demonstrate an organizational understanding of implementation of data governance, standard dictionaries, and data management.	• The new information gained from BI initiatives has become common knowledge. • Knowledge discovery and utilization is dynamic and active across the enterprise. • New knowledge gained is part of process improvement activities across the enterprise and is used to make regular decisions throughout the enterprise.
People and Team Processes		**Level 1: Initial**	**Level 2: Managed**	**Level 3: Defined**	**Level 4: Quantitatively Managed**	**Level 5: Optimizing**
Processes focused on project management and methodology related factors	**PM Standards**	• Project management standards have not been fully developed or are not necessarily tied to enterprise goals.	• Project management standards and expectations have been developed and are tied to enterprise goals. • Key stakeholders are involved in the BI projects.	• Project management standards, processes, and procedures are followed on a consistent basis.	• Project management standards from external industry associations are generally used to design and manage projects as appropriate for their scope and impact.	• The project management approach, staffing, management, and design are continually being evaluated for improvement (i.e., lessons learned).
	PM Methodology Related Factors	• Project management is not consistently applied throughout the organization.	• In general, there is an appropriate mix of skilled people (IT and business users) on project teams. • Projects are inventoried and tracked in silos, with some projects gaining more exposure or coordination based on their scope and leadership.	• Project results are reliable and outcomes are generally predictable and as expected. • All projects are tracked in a single place within the enterprise.	• Projects are monitored using quantitative tools for processes such as time, cost, and scope. • Project status reporting is shared across the enterprise as appropriate. • Specific targets have been established for quality and performance. • The project targets are managed with	• Projects are evaluated after completion by comparing initial estimations and goals against final results, including processes, planning, management, deliverables, reporting, and other collateral. • Projects are tracked at an enterprise level and verified for alignment and congruency with organizational short term goals, and long term

					quantitative tools.	mission and vision.
Processes focused on change management	**CM Culture**	• Change is resisted and can be avoided without consequence. • Change has the increased potential of producing unintended and/or detrimental consequences.	• Change management is often reactive.	• Change is more often proactive than reactive within an enterprise. • There is regular and frequent communication to key stakeholders regarding change.	• Systematic evaluation of proposed changes is undertaken.	• There is a culture of continuous improvement throughout the enterprise. • Change is embraced, organized, and easy to affect; it cannot be avoided or misaligned with organization goals without management's knowledge. • The culture of change is supported by management throughout the enterprise.
	CM Methodology	• The change impact on budget, schedule, staffing, and other factors is often estimated or not known. • When changes are implemented, there is not necessarily a strong connection between the change and the overall goals of the enterprise.	• There are enterprise standards for critical processes; departments migrate to and coordinate their processes to support the standard. • Change management initiatives are overseen by executives but may not be closely monitored or controlled.	• The quantity, quality, frequency, and impact of organizational wide change is estimated, managed, and controlled across the enterprise. • Change management initiatives are standardized and consistently managed across the enterprise.	• Targets for quality and performance are established resulting in change initiatives that meet goals. • Metrics have been agreed upon by following standards established through data governance. • The results of change are monitored with quantitative tools to determine the impact on the enterprise.	• Change is managed at a tolerable pace and volume as appropriate for different areas of the organization and their resources (both technical and staff.)
Processes focused on team and individual skill levels/needs	**Skills and Training**	• Training and skill levels for BI do not necessarily align with the needs of the overall enterprise.	• Training, skill set, requirements, education, and application infrastructure for BI initiatives have been established for both IT staff and business users. • The training and skill sets have primarily been defined and aligned	• The training, skills, education, and applications for BI initiatives that have been defined are aligned with organizational strategic goals. • Training and skill set coordination for BI is centralized and collectively managed for the	• Training and skill set requirements are monitored and evaluated for both IT staff and business users. • The business users and management staff are adequately trained to use the quantitative tools needed to use and understand BI reports and	• There is a culture of continuous improvement with ongoing training and education related to BI analysis and use. • The enterprise proactively determines the appropriate skill levels needed for new BI initiatives, and re-evaluates needs for existing processes and initiatives.

			with departmental goals. • There are skilled employees or outsourced services to manage, train, and be responsible for creating a learning environment.	enterprise.	dashboards. • Management drives the development for many of the reports and dashboards required for their department's initiatives.	• The enterprise manages staff and training to achieve and maintain the ongoing skill levels.
Technology Processes		**Level 1: Initial**	**Level 2: Managed**	**Level 3: Defined**		**Level 5: Optimizing**
Processes focused on strategic technology infrastructure	**Data Architecture**	• Data is retrieved out of individual departmental systems.	• A data architecture strategy is in place to include growing needs and types of information in a healthcare environment. • The role of IT is operator of the infrastructure and provider of standardized IT related services.	• A data warehouse is in place with integrated data. • A BI strategy addresses the technical infrastructure requirements. • The role of IT is a business partner working with business users.	• The data warehouse has "one source for the truth" (i.e., the data warehouse contains the standard master data on a patient across all information systems in the enterprise.)	• Information is readily available to the end user and key stakeholders.
	Data Collection and Usage	• Information is primarily obtained from static reports or non-electronic sources (i.e., paper charts, calendars, intake sheets) which are prone to transcription error when inputting paper-based data into electronic format. • Various reports showing similar or related data that should be consistent are not or vary inconsistently.	• Static reports are the typical source for information. • Data collection and reporting are infrequent, inconsistent, or as requested. • Real-time reporting is used in some departments, but the overall use is minimal.	• Performance tools are available and used by the front-end user for information needed for PI. • Data collection and reporting are scheduled and at regular intervals. • Data collection and reporting are consistent and persistent.	• The ability to retrieve and use the data is flexible and available to the business users. • Predictive analytics, data mining, and data visualization tools (such as dashboards) are used on a regular basis. • Reporting is typically on a long term view (weekly, monthly, quarterly, or longer) although some reports may be on a short term view.	• Information is used on a regular basis for continuous process improvement at all levels of the enterprise. • Dynamic and real-time data collection and reporting is available for all appropriate organizational metrics.

Processes focused on data quality	**Data Standardization**	• The definitions of data are inconsistent across information systems and departments. • The format of data is inconsistent across information systems and departments.	• There are some efforts to standardize data, but they are not consistent across the enterprise. • Data is structured in a way to specifically address individual needs for reporting. • The enterprise has recognized the importance of standards. • Skilled people have been put into place to manage the quality of the data.	• There are standardized definitions for data that are used in BI initiatives across the enterprise. • Metadata is regularly referenced and seen as the key for defining data fields in all systems. • Metadata is managed as a corporate asset and responsibility. • There is an enterprise standard for metadata that is published and referenced consistently.	• Measurable targets for quality and performance are in place using quality data. • Data collection and reporting have built in data quality thresholds for validation.	• Quality data is used to analyze and understand the causes of variation in a process. • Strategic information is trustworthy and used for strategic decision making.
	Data Governance	• BI initiatives and responsibilities including infrastructure management, data validation, data standardization are non-existent, inconsistent, or decentralized within the enterprise.	• The BI organization and responsibilities are managed and defined for specific projects, and may inconsistently focus on governance structure.	• There is a data governance council in place consisting of members from IT and the business user community. The council focuses on BI and analytical programs, projects, practices, software, architecture, data validation, data standardization, data quality, data elements, data normalization, data origination, data stewardship, and data chain of control.	• There are processes for evaluation and oversight of quantitative analysis. • Data governance is an enterprise initiative and is appreciated by senior management because of the focus on standardization, consistency, and quality of data.	• The organization has a coordinated and organized approach for dynamic reporting on all key organizational metrics, performance in an on-demand manner that occurs with regular frequency with both a short term and long term view.
Processes Specific to Complexities in Healthcare		**Level 1: Initial**	**Level 2: Managed**	**Level 3: Defined**	**Level 4: Quantitatively Managed**	**Level 5: Optimizing**

Processes focused on administrative (operational and financial) data	**Administrative Data Integration and Usage**	• There is some, but minimal, integration of administrative data among departmental applications within the enterprise. • Administrative data across applications is inconsistent. • There is not a conscious rollout strategy to integrate administrative data across different departmental applications when purchasing IT systems.	• There are enterprise goals to evaluate administrative systems, such as operational and financial systems, for the integration of applications. • There are adequate staffing levels in place to implement and support the administrative applications.	• There are defined data definition standards to allow for easy integration of administrative applications across various systems. • There is standardization of the "sources" of administrative data. • Administrative systems conform and communicate effectively. • Consistent results are obtained because of integration of administrative systems.	• Performance improvement activities often include the use of key performance indicators (KPIs) which include critical administrative data. • Administrative information is used for predictive analytics.	• Process improvement activities are driven by administrative data. • Administrative data is continuously used to manage and improve the organization, and to track both past and future performance in a dynamic way.
Processes focused on clinical data	**Clinical Data and Integration of Usage**	• There is some, but sporadic or minimal, integration of clinical data among the various clinical applications within the enterprise. • Clinical data across applications is inconsistent or non-existent, causing redundancies in collecting data. • There is not a conscious rollout strategy to integrate clinical data across other clinical applications when	• There are enterprise goals to evaluate clinical systems for the integration of applications. • There are adequate staffing levels in place to implement and support the clinical applications.	• There are defined data definition standards to allow for easy integration of clinical applications across various clinical systems. • New applications and systems always have data standards and integration addressed as part of the implementation, education, and rollout process. • Consistent results are obtained because of the integration of clinical systems. • The organization pursues evidence-based medicine tools	• Performance improvement activities include the use of key performance indicators (KPIs) which include clinical data. • Clinical information is used for predictive analytics. • Patient care staff dashboards are in use to identify targets of opportunities for clinical improvement initiatives. • Patient care staff decision support is used to help with complex treatment decisions. • The organization implements evidence-	• On a regular basis, clinical information is available at the point of care, often evidence-based, in support of making clinical decisions. • Process improvement activities include clinical information used on a regular basis to make decisions.

		purchasing information systems.		to support clinical decision making.	based medicine tools.	
Processes focused on the integration of administrative and clinical data	**Integration and Usage of Administrative and Clinical Data**	• There is some, but minimal, integration of administrative and clinical information. • There is not a conscious rollout strategy to integrate administrative and clinical information when purchasing information systems.	• There is a mechanism in place to evaluate and plan for the integration of core administrative and clinical data. • There are adequate staffing levels in place to interface and support the core administrative and clinical systems. • Skilled people are in place to interface the variety of types of information. • Administrative and clinical data is managed and coordinated by an organizational entity.	• There are defined data definition standards (metadata) to allow for easy integration of administrative and clinical systems. • New applications and systems always have data standards and integration addressed as part of the implementation, education, and rollout process.	• Performance improvement activities include integrated information from administrative and clinical data. • Integrated administrative and clinical information is used for predictive analytics.	• Process improvement activities include administrative and clinical information that is used together to make decisions. • On a regular basis, information to make decisions (clinical with integrated administrative integration) is available at the point of care, often evidence-based. • The variances between data sources and systems and types of data are isolated due to management and coordination of data.
Processes focused on the exchange and interoperability of external data	**Exchange and Interoperability of External Data**	• There are inconsistent data definitions between internal and external data. • Interpretation and use of external data is difficult because of the lack of data standards.	• There are some efforts in standard data definitions between internal and external data. • There is a process in place to monitor, control, and review the internal versus external data. • The organization is reviewing options for participation in regional data exchanges.	• Standard data definitions (metadata) are defined and used on a regular basis for both internal and external data. • The regular use of industry standards for nomenclature and classification systems is used. • The organization engages in the support of the development and management of local and regional	• Statistical and quantitative tools are used to manage internal and external data for performance improvement activities. • Predictive modeling includes both internal and external data.	• External data is fully integrated into internal data systems. • External data is used on a regular basis for continuous quality and process improvement of internal processes across the enterprise.

				data exchanges.		

APPENDIX F: BI PARTICIPANT SUMMATIVE EVALUATION

Evaluation of Healthcare BI Maturity Model Design

The purpose of the evaluation of the healthcare BI maturity model design is to: (1) evaluate the overall design of the model itself and (2) evaluate the organizational BI maturity level assessment tool to be used within a healthcare organization to assess BI maturity.

The evaluation will reference the problem requirements, maturity model design, and organizational BI maturity level assessment tool. The problem requirements and iterative maturity model design should be very familiar to you; the organizational BI maturity level assessment tool is new, but is taken from the leveling work that has already been done when the model was designed. The documents can be referenced as follows:

- Problem requirements list: Ref.Requirements
- Maturity model design: Ref.Model
- Organizational BI maturity level assessment tool: Ref.Assessment

If you have any questions about this questionnaire, please contact Patti Brooks at patti.brooks@avera.org or (605) 995-2502. The anticipated time to complete the questionnaire is approximately 15 – 20 minutes. Please return the completed questionnaire to patti.brooks@avera.org.

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Use the Tab or down arrow key to move from box to box to fill in your answers. Click inside the box to select an answer. Click again inside the box to unselect an answer. In areas where free text comments are asked, use the Tab or down arrow key to get to the boxed area and just start typing your response.

In order to get your perspective on the completeness of the maturity model, please review each problem requirement and complete your responses using the following rating:

1 = Strongly Disagree 2 = Disagree 3 = Uncertain 4 = Agree 5 = Strongly Agree

The completed maturity model is the Ref.Model document.

Evaluation of Overall Maturity Model Design
Problem Requirements Included in the Maturity Model Design
Problem #1: Provide a conceptual structure for evaluating the use of business intelligence in healthcare.

I feel requirement #1 is met with the design of the proposed maturity model.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Problem #2: Focus on the needs of operational/financial and clinical information.	
I feel requirement #2 is met with the design of the proposed maturity model.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Problem #3: Focus on capturing key business and clinical intelligence processes and practices, taking into consideration specific processes within healthcare.	
I feel requirement #3 is met with the design of the proposed maturity model.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Problem #4: Incorporate key processes that include people, technology, and organizational processes.	
I feel requirement #4 is met with the design of the proposed maturity model.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Problem #5: Incorporate aspects of quality including system quality, information quality, and service quality.	
I feel requirement #5 is met with the design of the proposed maturity model.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Problem #6: Provide an understanding of relationships between the different levels and key processes involved in a maturity model by incorporating theoretical underpinnings.	
I feel requirement #6 is met with the design of the proposed maturity model.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	

If you feel there is anything missing in the maturity model design that you have not already commented on, please explain:

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In order to get your perspective on the quality of the organizational BI maturity level assessment tool which will be piloted within a healthcare system, I would really appreciate you taking a few minutes to review the assessment statements for each process and complete your responses using the following rating:

1 = Strongly Disagree 2 = Disagree 3 = Uncertain 4 = Agree 5 = Strongly Agree

The organizational BI maturity level assessment tool is the Ref.Assessment document.

Evaluation of Organizational BI Maturity Level Assessment Tool	
Processes focused on vision and strategy	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I feel the statements are presented in a manner the user will be able to understand.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Processes focused on management engagement and support	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I feel the statements are presented in a manner the user will be able to understand.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Processes focused on project management and methodology related factors	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I feel the statements are presented in a manner the user will be able to understand.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Processes focused on change management	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I feel the statements are presented in a manner the user will be able to understand.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Processes focused on team and individual skill levels/needs	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I feel the statements are presented in a manner the user will be able to understand.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Comments:	
Processes focused on strategic technology infrastructure	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I feel the statements are presented in a manner the user will be	1 2 3 4 5

able to understand.	☐ ☐ ☐ ☐ ☐
Comments:	
Processes focused on data quality	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
I feel the statements are presented in a manner the user will be able to understand.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
Comments:	
Processes focused on data standardization and governance	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
I feel the statements are presented in a manner the user will be able to understand.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
Comments:	
Healthcare - Processes focused on administrative (operational and financial) data	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
I feel the statements are presented in a manner the user will be able to understand.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
Comments:	
Healthcare – Processes focused on clinical data	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
I feel the statements are presented in a manner the user will be able to understand.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
Comments:	
Healthcare – Processes focused on integrated data	
I feel the statements adequately reflect functionality at each maturity level in this process.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
I feel the statements are presented in a manner the user will be able to understand.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
Comments:	
Healthcare – Processes focused on external data	
I feel the statements adequately reflect functionality at each	1 2 3 4 5

maturity level in this process.	☐ ☐ ☐ ☐ ☐
I feel the statements are presented in a manner the user will be able to understand.	1 2 3 4 5 ☐ ☐ ☐ ☐ ☐
Comments:	

An assessment questionnaire is obviously only one method to evaluate a maturity level, and in most cases, would probably not be the only method of assessment used within a healthcare organization. Within the questionnaire itself, please comment on anything you feel is missing from the organizational BI maturity level assessment tool that you have not mentioned above:

Thank you for taking the time to complete this questionnaire. Your expertise and feedback are greatly appreciated and will contribute to the overall quality of this research.

APPENDIX G: INITIAL ORGANIZATIONAL BI MATURITY LEVEL ASSESSMENT TOOL FOR BIMM

Organizational BI Maturity Level Assessment Tool for a

Business Intelligence Maturity Model for Healthcare

The purpose of this tool is twofold. I am working on my dissertation which consists of developing a business intelligence maturity model specifically for healthcare. In order to validate the construction of my maturity model, I would like to validate it within an organization to determine if the maturity leveling and processes are solid. In addition, it allows this organization an opportunity to develop a perspective on where they are at with the use and maturity of business intelligence. In this regard, the results of the tool serve as a readiness assessment tool for the development of a strategy to effectively and progressively use business intelligence within a healthcare organization. For those of you who are familiar with the EMR Adoption Model by HIMSS Analytics, the concept is very similar.

Definitions to use in this tool:

Business intelligence (BI): Business intelligence (BI) is a broad category of technologies, applications, and processes for gathering, accessing, and analyzing data to make better decisions. This is combined data from clinical, financial, and other applications. Because this assessment is specific to healthcare, business intelligence will include the use of clinical intelligence.

Organizations use business intelligence to gain data-driven insights on anything related to business performance. It is used to understand and improve performance and to cut costs and identify new business opportunities. Examples include:

- Tracking financial and clinical performance
- Optimizing processes and operational performance
- Measuring, tracking, and predicting particular types of patient discharges and diagnoses
- Improving patient satisfaction and consumer relationships
- Analyzing risk
- Analyzing strategic value

One easy way to think about business intelligence is….getting the right information to the right people at the right time so they can make good decisions that improve organizational performance.

Enterprise or Organization: Organized business activities for the entire healthcare system.

Facility: The individual facility where you work.

What is your primary type of facility where you work:

_____ Acute care hospital

_____ Long term care facility

_____ Ambulatory clinic

_____ Home care agency

_____ Other (Please list): _____

What is your primary job function within your facility:

_____ CEO/Administrator

_____ COO/VP of Operations

_____ CFO/VP of Finance

_____ CNO/VP of Nursing

_____ CIO/RIO/IT Management

_____ Quality/Risk Management

_____ Physician/Medical Information Officer

_____ Other (Please list, including if designee for above categories):

_____

Please provide the unique number that was given to you to complete this questionnaire. This information is strictly to remove any duplicate survey responses. Unique ID#: _____

To the best of your knowledge, please indicate the extent to which you agree or disagree with each statement using the following rating scale:

1 = Strongly Disagree 2 = Disagree 3 = Uncertain 4 = Agree 5 = Strongly Agree

Please use the comment area to include any clarifying information or give suggestions for making the statements more relevant or easier to understand.

BI Vision and Strategy	**Code**	**1**	**2**	**3**	**4**	**5**
1. BI initiatives and responsibilities are decentralized within the organization.	OVS1					
2. There may be some BI initiatives in place, but they are not consistently managed throughout the organization.	OVS2					
3. There are defined standards for the development and operations of BI initiatives.	OVS3					
4. BI initiatives are prioritized, in part, based on added value to the organization.	OVS4					
5. There is a comprehensive BI strategy that is aligned with the organization's vision and strategy.	OVS5					
Comments:						
Management Engagement and Support	**Code**	**1**	**2**	**3**	**4**	**5**
6. Management may have some interest in BI, but does not necessarily understand the resources that are needed for a strong BI process across the organization.	OMS1					
7. Management understands the resources needed for BI initiatives, including various costs, efforts related to time and materials, technology infrastructure, as well as both technical and clinical staff expertise, skills, and training.	OMS2					
8. Management provides the resources needed for BI initiatives, including cost, time, technology, and staff.	OMS3					
9. Management is engaged in measurement, tracking, and reporting through the use of analytics across all areas of the organization.	OMS4					
10. Management is engaged in BI and clinical intelligence (CI) initiatives and they are consistently used for continuous process improvement for both clinical and business processes throughout the organization.	OMS5					
Comments:						
Learning Organization	**Code**	**1**	**2**	**3**	**4**	**5**

11. The recording and sharing of information across the organization is not necessarily routine and second nature.	OLO1					
12. There are goals for the sharing of information and knowledge gained from BI initiatives.	OLO2					
13. The information and knowledge gained from BI initiatives is managed and shared in a consistent, standard way.	OLO3					
14. Information and knowledge gained through the evaluation of new patterns and relationships (data mining) is shared throughout the facility.	OLO4					
15. There is a culture of continuous learning with an evolution and maturation of ways BI and analytics can support and move the organization forward.	OLO5					
Comments:						
Project Management	**Code**	**1**	**2**	**3**	**4**	**5**
16. Project management is not consistently applied throughout the organization.	PPM1					
17. Project management standards and expectations have been developed but they may not be followed on a consistent basis.	PPM2					
18. Project management standards, processes, and procedures are followed on a consistent basis.	PPM3					
19. Projects are monitored using quantitative tools for processes such as time, cost, and scope.	PPM4					
20. Projects are evaluated after completion by comparing initial estimations and goals against final results, including processes, planning, management, deliverables, reporting, and other collateral (i.e., lessons learned).	PPM5					
Comments:						
Change Management	**Code**	**1**	**2**	**3**	**4**	**5**
21. The change impact on budget, schedule, staffing, and other factors is often estimated or not known.	PCM1					
22. There may be organizational standards for critical change management processes, but departments tend to migrate to and coordinate their own processes to support the standard.	PCM2					
23. Change management initiatives are standardized and consistently managed across the organization.	PCM3					
24. The results of change are monitored with quantitative tools to determine the impact on the organization.	PCM4					
25. There is a culture of change and continuous improvement	PCM5					

throughout the organization.						
Comments:						
People and Team Skills	**Code**	**1**	**2**	**3**	**4**	**5**
26. The training and skill levels for BI are not known or do not necessarily align with the needs of the overall organization.	PPT1					
27. The training, skill set, requirements, education, and application infrastructure for BI initiatives have been defined for both IT staff and business users but are primarily aligned with departmental goals.	PPT2					
28. The training, skills, education, and applications for BI initiatives have been defined for both IT staff and business users and they are aligned with organizational strategic goals.	PPT3					
29. The business users and management staff are adequately trained to use the quantitative tools needed to use and understand BI reports and dashboards.	PPT4					
30. The organization proactively determines the appropriate skill levels needed for new BI initiatives, and re-evaluates needs for existing processes and initiatives.	PPT5					
Comments:						
Data Architecture	**Code**	**1**	**2**	**3**	**4**	**5**
31. Tools to retrieve and analyze data are ad hoc and inconsistent.	TDA1					
32. A data architecture strategy is in place to include growing needs and types of information in a healthcare environment.	TDA2					
33. Data cleansing and extract, transform, and load (ETL) processes are understood and standardized across the organization.	TDA3					
34. There is a data warehouse in place which has "one source for the truth" (i.e., the data warehouse contains the standard master data on a patient across all information systems in the organization.)	TDA4					
35. Information to make decisions is readily available and routinely used by the end users and key stakeholders because the data architecture and tools to retrieve data are in place.	TDA5					
Comments:						

Data Quality	**Code**	**1**	**2**	**3**	**4**	**5**
36. The data and reports may or may not produce useful or consistent information.	TDQ1					
37. Real-time reporting is used in some departments, but the overall use is minimal.	TDQ2					
38. Data collection and reporting methods are standardized and are consistent.	TDQ3					
39. Predictive analytics, data mining, and data visualization tools (such as dashboards) are used on a regular basis.	TDQ4					
40. Strategic information is trustworthy and used for strategic decision making.	TDQ5					
Comments:						
Data Standardization and Governance	**Code**	**1**	**2**	**3**	**4**	**5**
41. The definitions and format of data are inconsistent across information systems and departments.	TSG1					
42. There are some efforts to standardize data, but they are not consistent across the organization.	TSG2					
43. There is a data governance council in place consisting of members from IT and the business user community. The council focuses on BI and analytical programs, projects, practices, software, architecture, data validation, data standardization, data quality, data elements, data normalization, data origination, data stewardship, and data chain of control.	TSG3					
44. Because of the standardized nature that data is collected and reported, information contained in reports is consistent and can be trusted.	TSG4					
45. Key metrics include standardized consistent data and are used for continuous process improvement activities throughout the organization.	TSG5					
Comments:						
Healthcare – Administrative and Financial Data	**Code**	**1**	**2**	**3**	**4**	**5**
46. There are redundancies in data collection because of duplicate administrative and financial applications, such as two different registration systems.	HCA1					
47. There are organizational processes to evaluate administrative and financial systems for the integration of applications.	HCA2					
48. There are identified key performance indicators (KPIs) for administrative and financial data, but they are not known or consistently used throughout the organization.	HCA3					
49. Key performance indicators (KPIs) including	HCA4					

administrative and financial data are used for performance improvement activities on a regular basis.						
50. Process improvement activities are driven by administrative and financial data.	HCA5					
Comments:						
Healthcare – Clinical Data	**Code**	**1**	**2**	**3**	**4**	**5**
51. There are redundancies in data collection because of duplicate clinical systems, such as queries in two different systems that technically serve the same purpose.	HCC1					
52. There are organizational processes to evaluate clinical systems for the integration of applications.	HCC2					
53. There are identified key performance indicators (KPIs) for clinical data, but they are not known or consistently used throughout the organization.	HCC3					
54. Key performance indicators (KPIs) including clinical data are used for performance improvement activities on a regular basis.	HCC4					
55. Process improvement activities are driven by clinical data.	HCC5					
Comments:						
Healthcare – Integrated Data	**Code**	**1**	**2**	**3**	**4**	**5**
56. The value of embedding analytics into clinical and business processes is not necessarily considered when implementing or optimizing systems.	HCI1					
57. There is a mechanism in place to evaluate and plan for the integration of core administrative, financial, and clinical data.	HCI2					
58. New applications and systems have data integration addressed on a regular basis as part of the implementation, education, and rollout process.	HCI3					
59. The integration of administrative, financial, and clinical data is used for predictive analytics.	HCI4					
60. Process improvement activities are driven by integrated administrative, financial, and clinical data.	HCI5					
Comments:						
Healthcare – External Data	**Code**	**1**	**2**	**3**	**4**	**5**
61. The interpretation and use of external data is difficult because of the lack of data standards.	HCE1					
62. There are some efforts in standard data definitions between internal and external data.	HCE2					
63. Standard data definitions, including the use of industry standards for nomenclature and classification systems, are	HCE3					

used on a regular basis for both internal and external data (i.e., ICD-9/ICD-10, CPT, SNOMED, LOINC, and RxNorm).						
64. The organization participates in external benchmarking for key processes.	HCE4					
65. External data is fully integrated into internal data systems and used for process improvement (i.e., through the use of a regional data exchange.)	HCE5					
Comments:						

APPENDIX H: UNSTRUCTURED SORTING QUESTIONNAIRE

Unstructured Card Sorting

My dissertation consists of creating a business intelligence maturity model for healthcare. The purpose of the card sorting exercise is to evaluate the soundness of the categorization of the statements in my organizational BI maturity level assessment tool.

I am providing you with the statements I am intending to ask in my assessment tool. I am intentionally not including information on the categories to which they are assigned. Your job is to read the statements and sort them into "like" categories. You can create as many categories as you feel are necessary, but try to keep them manageable, i.e. probably no more than 12-15. Don't worry if you do not have an equal number of statements falling into the same category. If there are statements that don't seem to fit a category, put them in a "no category" section. If there are statements that seem to fit into two categories, go ahead and include them in both categories.

Because we are not working with physical cards or strips of paper, I think the easiest way to do this activity would be to: (1) Read through all the statements, (2) Cut and paste the like statements so they are together and then (3) Give that group of statements a category name. Please make sure when you are cutting the statement, that you include the statement number as well. I have included a template at the end of this document that you may use. It is anticipated this process will take approximately 20 to 25 minutes to complete.

If you have any questions, please feel free to contact me at pbrooks@santel.net or (605) 770-5096 (cell). When you complete the activity, you can e-mail the document back to me. Thanks in advance for your assistance. This is an important step in the validation portion of my dissertation, and I really appreciate you being a part of that.

Example:

Category: Communication

Statements that seem to fit this category:

10. I feel like no one ever tells me anything about what's going on around here.

16. I am thorough satisfied with the information I receive about what's going on at DSU.

8. My performance would improve if I received more information about what's going on around here.

22. The people who know what's going on at DSU do not share information with me.

Assessment statements in randomized order:

1. Change management initiatives are standardized and consistently managed across the organization.

2. Standard data definitions, including the use of industry standards for nomenclature and classification systems, are used on a regular basis for both internal and external data (i.e., ICD-9/10, CPT, SNOMED, LOINC, and RxNorm).

3. Management is engaged in measurement, tracking, and reporting through the use of analytics across all areas of the organization.

4. The data and reports may or may not produce useful or consistent information.

5. There are identified key performance indicators (KPIs) for clinical data, but they are not known or consistently used throughout the organization.

6. There are redundancies in data collection because of duplicate clinical systems, such as queries in two different systems that technically serve the same purpose.

7. Process improvement activities are driven by administrative and financial data.

8. The integration of administrative, financial, and clinical data is used for predictive analytics.

9. The interpretation and use of external data is difficult because of the lack of data standards.

10. There is a culture of change and continuous improvement throughout the organization.

11. The change impact on budget, schedule, staffing, and other factors is often not estimated or not known.

12. Information to make decisions is readily available and routinely used by the end users and key stakeholders because the data architecture and tools to retrieve data are in place.

13. There are goals for the sharing of information and knowledge gained from BI initiatives.

14. The recording and sharing of information across the organization is not necessarily routine and second nature.

15. Project management standards and expectations have been developed but they may not be followed on a consistent basis.

16. The value of embedding analytics into clinical and business processes is not necessarily considered when implementing or optimizing systems.

17. Because of the standardized nature that data is collected and reported, information contained in reports is consistent and can be trusted.

18. The organization proactively determines the appropriate skill levels needed for BI initiatives, and re-evaluates needs for existing processes and initiatives.

19. Management may have some interest in BI, but does not necessarily understand the resources that are needed for a strong BI process across the organization.

20. Process improvement activities are driven by clinical data.

21. Information and knowledge gained through the evaluation of new patterns and relationships (data mining) is shared throughout the facility.

22 Data collection and reporting methods are standardized and are consistent.

23. External data is fully integrated into internal data systems and used for process improvement (i.e., through the use of a regional data exchange.)

24. Project management is not consistently applied through the organization.

25. Strategic information is trustworthy and used for strategic decision making.

26. A data architecture strategy is in place to include growing needs and types of information in a healthcare environment.

27. Management is engaged in BI and clinical intelligence (CI) initiatives and they are consistently used for continuous process improvement for both clinical and business processes throughout the organization.

28. There is a culture of continuous learning with an evolution and maturation of ways BI and analytics can support and move the organization forward.

29. The training and skill levels for BI are not known or do not necessarily align with the needs of the overall organization.

30. Tools to retrieve and analyze data are ad hoc and inconsistent.

31. There is a data warehouse in place which has “one source for the truth” (i.e., the data warehouse contains the standard master data on a patient across all information systems in the organization.)

32. There is a data governance council in place consisting of members from IT and the business user community. The council focuses on BI and analytical programs, projects, practices, software, architecture, data validation, data standardization, data quality, data elements, data normalization, date origination, data stewardship, and data chain of control.

33. Process improvement activities are driven by integrated administrative, financial, and clinical data.

34. The business users and management staff are adequately trained to use quantitative tools for BI reports and dashboards.

35. Data cleansing and extract, transform, and load ETL processes are understood and standardized across the organization.

36. There may be organizational standards for critical change management processes, but departments tend to migrate to and coordinate their own processes to support the standard.

37. Management provides the resources needed for BI initiatives including cost, time, technology, and staff.

38. Real-time reporting is used in some departments, but the overall use is minimal.

39. Management understands the resources needed for BI initiatives, including various costs, efforts related to time and materials, technology infrastructure, as well as both technical and clinical staff expertise, skills, and training.

40. The definitions and format of data are inconsistent across information systems and departments.

41. Key performance indicators (KPIs) including administrative and financial data are used for performance improvement activities on a regular basis.

42. There are organizational processes to evaluate administrative and financial systems for the integration of applications.

43. There are identified key performance indicators (KPIs) for administrative and financial data, but they are not known or consistently used throughout the organization.

44. BI initiatives are prioritized, in part, based on added value to the organization.

45. The information and knowledge gained from BI initiatives is managed and shared in a consistent, standard way.

46. Key metrics include standardized consistent data and are used for continuous process improvement activities throughout the organization.

47. Project management standards, processes, and procedures are followed on a consistent basis.

48. New applications and systems have data integration addressed on a regular basis as part of the implementation, education, and rollout process.

49. Projects are monitored using quantitative tools for processes such as time, cost, and scope.

50. The results of change are monitored with quantitative tools to determine the impact on the organization.

51. Predictive analytics, data mining, and data visualization tools (such as dashboards) are used on a regular basis.

52. There are organizational processes to evaluate clinical systems for the integration of applications.

53. BI initiatives and responsibilities are decentralized within the organization.

54. There is a comprehensive BI strategy that is aligned with the organization's vision and strategy.

55. There are some efforts to standardize data, but they are not consistent across the organization.

56. Key performance indicators (KPIs) including clinical data are used for performance improvement activities on a regular basis.

57. The training, skill set, requirements, education, and application infrastructure for BI initiatives have been defined for both IT staff and business users but are primarily aligned with departmental goals.

58. There is a mechanism in place to evaluate and plan for the integration of core administrative, financial, and clinical data.

59. There are defined standards for the development and operations of BI initiatives.

60. The training, skills, education, and applications for BI initiatives have been defined for both IT staff and business users and they are aligned with organizational strategic goals.

61. Projects are evaluated after completion by comparing initial estimations and goals against final results, including processes, planning, management, deliverables, reporting, and other collateral (i.e., lessons learned).

62. There are redundancies in data collection because of duplicate administrative and financial applications, such as two different registration systems.

63. There are some efforts in standard data definitions between internal and external data.

64. There may be some BI initiatives in place, but they are not consistently managed throughout the organization.

65. The organization participates in external benchmarking for key processes.

Category:
Statements that seem to fit into this category:
Category:
Statements that seem to fit into this category:
Category:
Statements that seem to fit into this category:

Please include any comments about the sorting process or the clarity of the statements:

Again, thank you so much for your assistance!

APPENDIX I: STRUCTURED CARD SORTING QUESTIONNAIRE

Structured Card Sorting

My dissertation consists of creating a business intelligence maturity model for healthcare. The purpose of the card sorting exercise is to evaluate the soundness of the categorization of the statements in my organizational BI maturity level assessment tool.

I am providing you with the statements I am intending to ask in my questionnaire. I am also including the 12 categories and a brief explanation about each category. Your job is to read the statements and sort them into the category you feel best fits the statement.

Because we are not working with physical cards or strips of paper, I think the easiest way to do this activity would be to: (1) Read through all the statements, (2) Cut and paste each statement into the category that you feel most closely matches the statement. It is anticipated this process will take approximately 20 to 25 minutes to complete.

If you have any questions, please feel free to contact me at pbrooks@santel.net or (605) 770-5096 (cell). When you complete the activity, you can e-mail the document back to me. Thanks in advance for your assistance. This is an important step in the validation portion of my dissertation, and I really appreciate you being a part of that.

Example:

Category: Communication

Statements that seem to fit this category:

10. I feel like no one ever tells me anything about what's going on around here.

16. I am thorough satisfied with the information I receive about what's going on at DSU.

8. My performance would improve if I received more information about what's going on around here.

22. The people who know what's going on at DSU do not share information with me.

Assessment statements in randomized order:

1. External data is fully integrated into internal data systems and used for process improvement (i.e., through the use of a health information exchange.)

2. Key performance indicators (KPIs) including administrative and financial data are used for performance improvement activities on a regular basis.

3. Process improvement activities are driven by administrative and financial data.

4. There may be organizational standards for critical change management processes, but departments tend to migrate to and coordinate their own processes to support the standard.

5. Information to make decisions is readily available and routinely used by the end users and key stakeholders because the data architecture and tools to retrieve data are in place.

6. The organization is reviewing options for participation in at least one health information exchange.

7. There are standards in the use of the tools and database storage locations to retrieve and analyze data.

8. The organization proactively determines the appropriate skill levels needed for new BI initiatives, and re-evaluates needs for existing processes and initiatives.

9. New applications and systems have data integration addressed on a regular basis as part of the implementation, education, and rollout process.

10. BI initiatives include measured targets of performance relative to organizational vision and strategy.

11. Management understands the resources needed for BI initiatives, including various costs, efforts related to time and materials, technology infrastructure, as well as both technical and clinical staff expertise, skills, and training.

12. BI initiatives and responsibilities are decentralized within the organization.

13. Process improvement activities are driven by integrated administrative, financial, and clinical data.

14. Industry standards for nomenclature and classification systems (i.e., ICD-9/ICD-10, CPT, SNOMED, LOINC, and RxNorm) are used consistently for the integration of external data.

15. The integration of administrative, financial, and clinical data is used for predictive analytics, data mining, and data visualization (such as dashboards).

16. Project management for BI initiatives is not consistently applied throughout the organization.

17. Change management initiatives are standardized and consistently managed across the organization.

18. Project management standards, processes, and procedures are followed on a consistent basis.

19. Management may have some interest in BI, but does not necessarily understand the resources that are needed for a strong BI process across the organization.

20. Management is engaged in BI and clinical intelligence (CI) initiatives and they are embedded in continuous process improvement activities for both clinical and business processes on a consistent basis.

21. The training, skills, education, and applications for BI initiatives have been defined for both IT staff and business users and they are aligned with organizational strategic goals.

22. The value of embedding analytics into clinical and business processes is not necessarily considered when implementing or optimizing systems.

23. Interpretation and use of external data is difficult because of the lack of using industry data standards.

24. The business users and management staff are adequately trained to use the quantitative tools needed to use and understand BI reports and dashboards.

25. There are organizational processes to evaluate administrative and financial systems for the integration of applications.

26. There are standardized definitions for data that are used in BI initiatives across the organization.

27. There are organizational processes to evaluate clinical systems for the integration of applications.

28. A data architecture strategy is in place to include growing needs and types of information in a healthcare environment.

29. Projects are evaluated after completion by comparing initial estimations and goals against final results, including processes, planning, management, deliverables, reporting, and other collateral (i.e., lessons learned).

30. Key metrics include standardized consistent data and are used for continuous process improvement activities throughout the organization.

31. There are redundancies in data collection because of duplicate administrative and financial applications, such as two different registration systems.

32. The training, skill set, requirements, education, and application infrastructure for BI initiatives have been defined for both IT staff and business users but are primarily aligned with departmental goals.

33. Projects are monitored using quantitative tools for processes such as time, cost, and scope.

34. There may be some BI initiatives in place, but they are not consistently managed throughout the organization.

35. There are goals for the sharing of information and knowledge gained from BI initiatives.

36. There are redundancies in data collection because of duplicate clinical systems, such as queries in two different systems that technically serve the same purpose.

37. Management is engaged in measurement, tracking, and reporting through the use of analytics for all major business objectives.

38. There are defined standards for the development and operations of BI initiatives.

39. Data is typically retrieved out of individual departmental systems, separate databases, or inconsistent storage locations within the database where reports can be generated.

40. Predictive modeling includes data from both internal and external sources.

41. There is a mechanism in place to evaluate and plan for the integration of core administrative, financial, and clinical data.

42. The change impact on budget, schedule, staffing, and other factors is often estimated or not known.

43. Process improvement activities are driven by clinical data.

44. Key performance indicators (KPIs) including clinical data are used for performance improvement activities on a regular basis.

45. The results of change are monitored with quantitative tools to determine the impact on the organization.

46. There is a data warehouse in place which has “one source for the truth” (i.e., the data warehouse contains the standard master data on a patient across all information systems in the organization.)

47. The training and skill levels for BI are not known or do not necessarily align with the needs of the overall organization.

48. Because of the standardized nature that data is collected and reported, information contained in reports is consistent and can be trusted.

49. There are identified key performance indicators (KPIs) for clinical data, but they are not known or consistently used throughout the organization.

50. There is a culture of change and continuous improvement throughout the organization.

51. Sharing of information and knowledge gained across the organization is not necessarily routine or consistent.

52. There are some efforts to standardize data, but they are not consistent across the organization.

53. Information and knowledge gained through the evaluation of new patterns and relationships (data mining) is shared throughout the facility.

54. There are identified key performance indicators (KPIs) for administrative and financial data, but they are not known or consistently used throughout the organization.

55. There is a culture of continuous learning with an evolution and maturation of ways BI and analytics can support and move the organization forward.

56. The information and knowledge gained through BI is managed and shared in a consistent, standard way.

57. There is a comprehensive documented BI strategy that is driven by business objectives and provides stakeholders with better decision making capabilities to achieve the desired goals of the organization.

58. Management supports the need for a data governance council to oversee the information management functions of BI including software architecture, data validation, data standardization, and data quality.

59. Project management standards and expectations have been developed but they may not be followed on a consistent basis.

60. Data and reports may or may not produce useful or consistent information.

Category: BI Vision and Strategy **Explanation:** A BI vision drives better business performance because of the ability to make decisions based on appropriate use of information. A BI strategy aligns with enterprise goals, improves knowledge management, and enables the penetration of BI into business processes helping organizations with strategic, tactical, and operational decision making.
Statements that seem to fit into this category:
Category: Management Engagement and Support **Explanation:** One of the greatest challenges in BI initiatives is management and organizational commitment, including attitudes to change, time, cost, technology, and project scope. Committed engagement by management and adequate resources are key components of successful BI initiatives.
Statements that seem to fit into this category:
Category: Learning Organization **Explanation:** The goal of BI is to support better decision making. A learning organization facilitates the learning and knowledge gained from information and continuously transforms itself as an organization. Some of the ways this is done is through systems thinking, strong communication, a shared vision, team learning, and a willingness to make changes.
Statements that seem to fit into this category:

Category: Project Management **Explanation:** BI projects are typically different from transactional application projects. The project team must design a robust and maintainable architecture that can accommodate the needs in an emerging and changing environment. This requires highly competent team members. The BI team should be cross-functional and composed of both technical and business personnel.
Statements that seem to fit into this category:
Category: Change Management **Explanation:** In many cases, BI initiatives will trigger decisions that will require change for the organization. Appropriate scope and planning for change facilitate the flexibility and adaptability needed for change.
Statements that seem to fit into this category:
Category: People and Team Skills **Explanation:** BI initiatives often span many departments and demand extensive data and resources from the business units. Organizations tend to rely on their IT staff to be responsible for most system implementation projects. However, BI projects are different from transactional applications and require much more of a team approach. In addition, appropriate training not only for team members but also users of the data is very important.
Statements that seem to fit into this category:

Category: Data Architecture **Explanation:** One of the key critical success factors for BI that has been identified is that the technical framework of a BI system must be scalable and flexible in order to meet the dynamic business needs. Therefore, it is important to develop a scalable system framework that can allow additional data sources, attributes, and dimensional areas. The infrastructure also needs to accommodate external data sources. In the healthcare environment, this could mean information from patients, federal agencies, insurance companies, and other healthcare institutions.
Statements that seem to fit into this category:
Category: Data Quality and Standardization **Explanation:** Data quality is extremely important for a strong BI culture. Some of the core aspects of data quality include accuracy, accessibility, completeness, consistency, ease of interpretation, reliability, relevancy, and timeliness.
Statements that seem to fit into this category:
Category: Healthcare – Administrative and Financial Data **Explanation:** Administrative (or operational) and financial data often exist in separate proprietary information systems. This makes it challenging to consolidate data from various systems with incompatible data formats and definitions in order to make operational decisions.
Statements that seem to fit into this category:

Category: Healthcare – Clinical Data **Explanation:** Clinical data often resides in separate information systems. This makes it challenging to consolidate data from various clinical systems with incompatible formats and definitions in order to make clinical decisions.
Statements that seem to fit into this category:
Category: Healthcare – Integrated Data **Explanation:** Despite many efforts to implement electronic health records, clinical and financial data are still often segregated in separate silos in proprietary systems with incompatible formats. Clinical intelligence combines business intelligence with clinical data. It is important for healthcare scorecards and performance improvement efforts to include information to contain administrative, financial, and clinical information.
Statements that seem to fit into this category:
Category: Healthcare – External Data **Explanation:** Because patients are managed across the continuum of care in an accountable care environment, the information needs will be more challenging to gather and evaluate data from multiple sources. In addition, there is a growing need to connect with payers and regulating agencies as well as patients and to integrate information from outside information systems into the core electronic health records in the healthcare facilities. One of the ultimate capabilities to pull together information on the total patient experience across the continuum is predictive modeling.
Statements that seem to fit into this category:

Please include any comments about the sorting process or the clarity of the statements:

Again, thank you so much for your assistance!

APPENDIX J: ORGANIZATIONAL BI MATURITY LEVEL ASSESSMENT TOOL

BI Maturity Level Assessment Tool for a Business Intelligence Maturity Model for Healthcare

Thank you for participating in this important survey to assess business intelligence maturity within our organization. This can be used as a planning tool for developing a BI strategy by providing the insight into the critical steps and processes needed to reach a desired level of BI maturity.

As an introduction, a few definitions we will be using are listed below.

Business intelligence (BI): Business intelligence (BI) is a broad category of technologies, applications, and processes for gathering, accessing, and analyzing data to make better decisions. This is combined data from clinical, financial, and other applications. Because this assessment is specific to healthcare, business intelligence will include the use of clinical intelligence.

Organizations use business intelligence to gain data-driven insights on anything related to business performance. It is used to understand and improve performance and to cut costs and identify new business opportunities. Examples include:

- Tracking financial and clinical performance
- Optimizing processes and operational performance
- Measuring, tracking, and predicting particular types of patient discharges and diagnoses
- Improving patient satisfaction and consumer relationships
- Analyzing risk
- Analyzing strategic value

One easy way to think about business intelligence is….getting the right information to the right people at the right time so they can make good decisions that improve organizational performance.

Enterprise or Organization: Organized business activities for the entire healthcare system.

Facility: The individual facility where you work.

Unless otherwise stated, this survey should be thought of as representing the entire healthcare system as a whole and not your individual facility.

It is anticipated this survey will take approximately 10 to 15 minutes to complete. You can save your work and come back to it if you do not have time to finish it at one time.

For the survey statements, please indicate to the best of your knowledge, your perception of the extent to which you agree or disagree with each statement using the following rating scale:

1 = Strongly Disagree 2 = Disagree 3 = Uncertain 4 = Agree 5 = Strongly Agree

Please use the comment area to include any clarifying information or give suggestions for making the statements more relevant or easier to understand.

****

In order to better understand your work environment, please answer the following demographic questions:

What is your primary type of facility where you work:

- ☐ Acute care hospital
- ☐ Ambulatory clinic
- ☐ Corporate office
- ☐ Home care agency
- ☐ Long term care facility
- ☐ Other (Please list):

What is your primary job function within your facility:

- ☐ Business/Clinical Intelligence
- ☐ CEO/Administrator

☐ COO/VP of Operations

☐ CFO/VP of Finance

☐ CNO/VP of Nursing

☐ CIO/RIO/IT Management

☐ Clinic Operations Management

☐ Project Management

☐ Quality/Risk Management

☐ Physician/Medical Information Officer

☐ Other (Please list, including if designee for above categories):

BI Vision and Strategy **Explanation:** A BI vision drives better business performance because of the ability to make decisions based on appropriate use of information. A BI strategy aligns with enterprise goals, improves knowledge management, and enables the penetration of BI into business processes helping organizations with strategic, tactical, and operational decision making. A BI strategy addresses many components, such as key performance indicators, data quality, data definitions, data accessibility, data storage, information needs throughout the organization, and the ability to use predictive analytics (to name a few).	**1**	**2**	**3**	**4**	**5**
1. BI initiatives and responsibilities are decentralized within the organization.	☐	☐	☐	☐	☐
2. Our organization may have some BI initiatives in place, but they are not consistently aligned with the organizational vision and strategy.	☐	☐	☐	☐	☐
3. Our organization has defined standards for the development and operations of BI initiatives which are aligned with organizational vision and strategy.	☐	☐	☐	☐	☐
4. Within our organization, BI initiatives include measured targets of performance that relate back to organizational vision and strategy.	☐	☐	☐	☐	☐
5. Our organization has a comprehensive documented BI strategy driven by business objectives.	☐	☐	☐	☐	☐

Comments:					
Management Engagement and Support **Explanation:** One of the greatest challenges in BI initiatives is management and organizational commitment, including time, cost, technology, project scope, and attitude to change. Committed engagement by management and adequate resources are key components of successful BI initiatives.	**1**	**2**	**3**	**4**	**5**
6. Senior management may have some interest in BI, but does not necessarily understand the resources that are needed for a strong BI process across the organization.	☐	☐	☐	☐	☐
7. Senior management understands the resources needed for BI initiatives, including cost, time, technology infrastructure, and technical and clinical staff expertise, skills, and training.	☐	☐	☐	☐	☐
8. Senior management supports the need for a data governance council to oversee the information management functions of BI including software architecture, data validation, data standardization, and data quality.	☐	☐	☐	☐	☐
9. All management levels are engaged in measurement, tracking, and reporting through the use of analytics for all major business objectives.	☐	☐	☐	☐	☐
10. All management levels are engaged in BI and clinical intelligence (CI) initiatives and they are embedded in continuous process improvement activities on a consistent basis.	☐	☐	☐	☐	☐
Comments:					
Learning Organization **Explanation:** The goal of BI is to support better decision making. A learning organization facilitates the learning and knowledge gained from information and continuously transforms itself as an organization. Some of the ways this is done is through systems thinking, strong communication, a shared vision, team learning, and a willingness to make changes.	**1**	**2**	**3**	**4**	**5**
11. Sharing of information and knowledge gained across the organization is not necessarily routine or consistent.	☐	☐	☐	☐	☐
12. There is a process in place to share information and knowledge gained through BI initiatives, but it may not be consistently followed throughout the organization.	☐	☐	☐	☐	☐
13. The information and knowledge gained through BI initiatives is managed and shared in a consistent, standard manner and format.	☐	☐	☐	☐	☐
14. Information and knowledge gained through the evaluation of new patterns and relationships (data mining) is shared throughout the organization on a regular basis.	☐	☐	☐	☐	☐
15. There is a culture of continuous learning with an evolution and maturation of ways BI and analytics can support and move the	☐	☐	☐	☐	☐

organization forward.					
Comments:					
Project Management **Explanation:** BI projects are typically different from transactional application projects. The project team must design a robust and maintainable architecture that can accommodate the needs in an emerging and changing environment. This requires highly competent team members. The BI team should be cross-functional and composed of both technical and business personnel.	**1**	**2**	**3**	**4**	**5**
16. Project management for BI initiatives is not consistently applied throughout the organization.	☐	☐	☐	☐	☐
17. Project management standards and expectations have been developed but they may not be followed on a consistent basis.	☐	☐	☐	☐	☐
18. Project management standards, processes, and procedures are followed on a consistent basis.	☐	☐	☐	☐	☐
19. Projects are monitored using quantitative tools for processes such as time, cost, and scope.	☐	☐	☐	☐	☐
20. Project management activities include evaluation after completion by comparing initial estimations and goals against final results, including processes, planning, management, deliverables, reporting, and other collateral (i.e., lessons learned).	☐	☐	☐	☐	☐
Comments:					
Change Management **Explanation:** In many cases, BI initiatives will trigger decisions that will require change for the organization. Appropriate scope and planning for change facilitate the flexibility and adaptability needed for change.	**1**	**2**	**3**	**4**	**5**
21. The change impact on budget, schedule, staffing, and other factors is often not estimated or known.	☐	☐	☐	☐	☐
22. There may be organizational standards for critical change management processes, but departments tend to migrate to and coordinate their own processes to support the standard.	☐	☐	☐	☐	☐
23. Change management initiatives are standardized and consistently managed across the organization.	☐	☐	☐	☐	☐
24. The results of change are monitored with quantitative tools to determine the impact on the organization.	☐	☐	☐	☐	☐
25. A culture of change and continuous improvement is prevalent throughout the organization.	☐	☐	☐	☐	☐
Comments:					
People and Team Skills **Explanation:** BI initiatives often span many departments and	**1**	**2**	**3**	**4**	**5**

demand extensive data and resources from the business units. Organizations tend to rely on their IT staff to be responsible for most system implementation projects. However, BI projects are different from transactional applications and require much more of a team approach. In addition, appropriate training not only for team members but also users of the data is very important.					
26. The training and skill level needs for BI initiatives may be evaluated, but not from an overall organization perspective.	☐	☐	☐	☐	☐
27. The training, skill set, requirements, education, and application infrastructure for BI initiatives have been defined for both IT staff and business users but they are primarily aligned with the perspective of individual departmental needs.	☐	☐	☐	☐	☐
28. The training, skills, education, and applications for BI initiatives have been defined for both IT staff and business users and they are aligned with organizational strategic goals.	☐	☐	☐	☐	☐
29. The business users and management staff are adequately trained to use the quantitative tools needed to use and understand BI reports and dashboards.	☐	☐	☐	☐	☐
30. The organization proactively determines the appropriate skill levels (analytical and technical) for new BI initiatives as well as existing process improvement activities.	☐	☐	☐	☐	☐
Comments:					
Data Architecture **Explanation:** One of the key critical success factors for BI that has been identified is that the technical framework of a BI system must be scalable and flexible in order to meet the dynamic business needs. Therefore, it is important to develop a scalable system framework that can allow additional data sources, attributes, and dimensional areas. The infrastructure also needs to accommodate external data sources. In the healthcare environment, this could mean information from patients, federal agencies, insurance companies, and other healthcare institutions.	**1**	**2**	**3**	**4**	**5**
31. Data is typically retrieved out of inconsistent storage locations, such as individual departmental systems, separate information systems, or different modules with inconsistent output within the database where reports can be generated.	☐	☐	☐	☐	☐
32. A data architecture strategy is in place to include growing needs and types of information in a healthcare environment.	☐	☐	☐	☐	☐
33. There are standards in the use of the tools and database storage locations to retrieve and analyze data.	☐	☐	☐	☐	☐
34. A data warehouse is in place which provides for "one source for the truth" (i.e., the data warehouse contains the standard master data on a patient across all information systems in the organization.)	☐	☐	☐	☐	☐

35. The data is organized and stored in a manner that provides for the ability for end users and key stakeholders to readily retrieve the information they need.	☐	☐	☐	☐	☐
Comments:					
Data Quality **Explanation:** Data quality is extremely important for a strong BI culture. Some of the core aspects of data quality include accuracy, accessibility, completeness, consistency, ease of interpretation, reliability, relevancy, and timeliness.	**1**	**2**	**3**	**4**	**5**
36. Reports may or may not produce useful or consistent information.	☐	☐	☐	☐	☐
37. There are some efforts to standardize data, but they are not consistent across the organization.	☐	☐	☐	☐	☐
38. There are standardized definitions for data that are used in BI initiatives across the organization.	☐	☐	☐	☐	☐
39. Because of the standardized nature that data is collected and reported, information contained in reports is consistent and can be trusted.	☐	☐	☐	☐	☐
40. There are standardized consistent data and definitions for the use of key metrics for continuous process improvement activities throughout the organization.	☐	☐	☐	☐	☐
Comments:					
Healthcare – Administrative and Financial Data **Explanation:** Administrative (or operational) and financial data often exist in separate proprietary information systems. This makes it challenging to consolidate data from various systems with incompatible data formats and definitions in order to make operational decisions. A few examples of key performance indicators (KPIs) for administrative/financial data include patient days; average length of stay; number of admissions, discharges, and transfers; and gross charges.	**1**	**2**	**3**	**4**	**5**
41. Duplicate administrative and financial systems are causing redundancies in data collection, i.e., two different registration or billing systems without the ability to integrate the data between systems.	☐	☐	☐	☐	☐
42. When new applications are being evaluated, there are organizational processes in place to evaluate administrative and financial systems for the integration of applications.	☐	☐	☐	☐	☐
43. Administrative and financial key performance indicators (KPIs) have been established but they are not consistently used throughout the organization.	☐	☐	☐	☐	☐

44. Administrative and financial data is included in key performance indicators (KPIs) within this organization on a regular basis.	☐	☐	☐	☐	☐
45. Administrative and financial data are included as a part of process improvement activities within this organization on a regular basis.	☐	☐	☐	☐	☐
Comments:					
Healthcare – Clinical Data **Explanation:** Clinical data often resides in separate information systems. This makes it challenging to consolidate data from various clinical systems with incompatible formats and definitions in order to make clinical decisions. A few examples of key performance indicators (KPIs) for clinical data include clinical outcomes, ER wait times, lab turnaround times, hospital acquired infections, and surgical site infections.	**1**	**2**	**3**	**4**	**5**
46. There are redundancies in data collection because of duplicate clinical systems, such as queries in two different systems that technically serve the same purpose.	☐	☐	☐	☐	☐
47. When new applications are being evaluated, there are organizational processes in place to evaluate clinical systems for the integration of applications.	☐	☐	☐	☐	☐
48. Clinical key performance indicators (KPIs) have been established but they are not consistently used throughout the organization.	☐	☐	☐	☐	☐
49. Clinical data is included in key performance indicators (KPIs) within this organization on a regular basis.	☐	☐	☐	☐	☐
50. Clinical data is included as a part of process improvement activities within this organization on a regular basis.	☐	☐	☐	☐	☐
Comments:					
Healthcare – Integrated Data **Explanation:** Despite many efforts to implement electronic health records, clinical and financial data are still often segregated in separate silos in proprietary systems with incompatible formats. Clinical intelligence combines business intelligence with clinical data. It is important for healthcare scorecards and performance improvement efforts to include information to contain administrative, financial, and clinical information.	**1**	**2**	**3**	**4**	**5**
51. The integration of operational and clinical data into clinical and business processes is not necessarily considered when implementing or optimizing systems.	☐	☐	☐	☐	☐
52. There is a mechanism in place to evaluate and plan for the integration of core administrative, financial, and clinical data.	☐	☐	☐	☐	☐
53. New applications and systems have data integration addressed on a regular basis as part of the implementation, education, and	☐	☐	☐	☐	☐

rollout process.					
54. The integration of administrative, financial, and clinical data is used for predictive analytics, data mining, and data visualization (such as dashboards).	☐	☐	☐	☐	☐
55. The integration of administrative, financial, and clinical data is included as a part of process improvement activities within this organization on a regular basis.	☐	☐	☐	☐	☐
Comments:					
Healthcare – External Data **Explanation:** Because patients are managed across the continuum of care in an accountable care environment, the information needs will be more challenging to gather and evaluate data from multiple sources. In addition, there is a growing need to connect with payers and regulating agencies as well as patients and to integrate information from outside information systems into the core electronic health records in the healthcare facilities. One of the ultimate capabilities to pull together information on the total patient experience across the continuum is predictive modeling. Predictive modeling includes the ability to analyze current and historical facts to make predictions about future events. For example, predictive modeling includes the ability to determine which patients are at risk of developing certain conditions, such as diabetes, asthma, and heart disease.	**1**	**2**	**3**	**4**	**5**
56. Sending and receiving information to and from external sources is difficult because of the lack of the usage of industry data standards.	☐	☐	☐	☐	☐
57. The organization is reviewing options for participation in at least one health information exchange as a mechanism to readily send/receive patient information from outside entities.	☐	☐	☐	☐	☐
58. The integration of external data is consistently being done through the use of industry standards for nomenclature and classification systems (i.e., ICD-9/ICD-10, CPT, SNOMED, LOINC, and RxNorm).	☐	☐	☐	☐	☐
59. Both internal and external sources of data are being used with predictive modeling.	☐	☐	☐	☐	☐
60. Data from external sources is fully integrated into internal information systems and used for process improvement (i.e., through the use of a health information exchange.)	☐	☐	☐	☐	☐
Comments:					

APPENDIX K: COMMENTS FROM THE QUANTITATIVE ORGANIZATIONAL BI MATURITY LEVEL ASSESSMENT

Section	Comments
OVS	Health care can be fragmented into what keeps the doors open, what regulation requires and proper care of patient and they do not always coincide.
	Although data available is often utilized, new data is difficult to obtain. System wide available reports will be the key to success. These reports need to be available to all facilities regardless of size.
	The BI strategy for this organization is in a state of evolvement. Many new initiatives are in progress; these questions will likely be answered much differently a year from now.
	I agree that in some instances we are beginning to align our data quest with our strategic goals, but believe we are in our infancy in thinking about this an entire enterprise.
	Patient quality measures such as value-based purchasing align with vision and strategy, but an overall BI strategy is not documented
	I am answering these questions from the framework of business intelligence and clinical intelligence.
	I am not sure what has been discussed at the corporate office for a BI vision and strategy; I think what we have is still done more at a regional level.
	Healthcare reform penalties have forced us to align and strategize together on many key metrics
	There is certainly a vision of where we need to be, and many components in getting there are in place or are being put into place over the next several months. I have not seen a documented strategy and the pieces we need seem to be added as we go on the fly.
	As of recent I have become more aware of BI initiatives and alignment within the organization that I was not aware of before
	There are Regional goals and target performance for BI, but I am uncertain if they support the overall goals of the organization.
	The CI Vision and Strategy exists as a public document within corporate.
	I have concerns about the decentralization and the number of added employees that will be billed back to the hospitals.
	I believe that new, in-progress initiatives will contribute to the centralization and value of BI in this organization.
OMS	What they sometimes do not realize is the personnel cost in training, incentives for doing such work (financial or in maintaining a work environment for these people that will keep them happy with their job and job performance)
	Need to eval cost of process. May be more feasible to purchase as a health system vs. individual facility. Many times cost is prohibitive for smaller facilities.
	We have made strides in this area but to say "ALL management levels....." is a stretch.
	I believe they are all involved in continuous process improvement on a consistent basis, perhaps not all of #13
	We have initiatives which are measured, tracked and reported, but it is not consistent among all facilities or even among all departments/management levels in an individual facility

	I believe it is difficult for service or support departments to always be engaged in these activities; in finding applicable data to monitor or review.
	Senior management certainly understands the cost, time, planning, etc. At times may under estimate those costs, but they are certainly aware of them being present.
	Most analytics at this time are purely volume focused
	Limited resources, technology & clinical expertise have severely impacted the processes
	There are the best of intentions out there, but am unsure if the consistency exists.
OLO	Regional facilities can be inconsistent in communicating to outreach sites. Some departments are better than others.
	I do think we are making progress but information is not consistent across the health system nor is it shared consistently with all managers
	I believe we try to share and use information the best we can, but there is still work to be done.
	Effective communication between areas and across the system is one of our biggest challenges and opportunity for improvement.
	We are trying to hardwire more of the data sharing, but it is a difficult process
	I may be too clinically embedded & as middle management I do not feel these are communicated consistently
	I am not completely sure of how BI analytics are shared across all levels of the organization.
	#16- Badly designed question.
	Often data that is filtered down to the hospitals is old data, that the hospital already know or has, or has supplied to the System
PPM	Small facility needs are not always addressed or met. May not always be feasible from a resource perspective to "do it all"
	Result evaluation is one of the key improvement initiatives in BI currently.
	Needs to be improved and consistently applied.
	We use project management for all major initiatives, unsure if clinical intelligence department is part of that. Also unsure if we are evaluating projects after completion - if it is done it is not reported to all levels of management
	To my knowledge there are not documented project standards or processes
	we have not developed consistent processes for BI, and the result is inconsistent practices across the system
	The PMO has an auditing department -- the QA team. There are standards for project methodology and templates. However, I am unsure if all BI initiatives are appropriately recognized as such and awareness exists that they may need a subset of specific methodologies that isn't standardized yet.
	#21-#25 responses apply to CI Projects only.
	PM comments apply to the PMO, not necessarily to BI initiatives, many of which are being done outside the standard PM structure.
PCM	Facilities tend to want to "do their own thing". Tools may be used but not always shared.
	#31 a culture of change is prevalent but not consistently the same facility to facility...each facility is doing their own thing
	The organization is continuously improving, but change management is not consistent

	Question 27 was not worded in a way that I completely understood - I answered assuming that you were asking about the change impact on projects in general, not just BI. Project management tries to quantify all changes, but cannot always accurately produce budget impacts as we don't have access to budgets, contracts, and other financials -- this is generally an area that that sponsor has to quantify the impact.
	The massive changes for centralization is creating chaos in the effort to keep up
PPT	Centralization of BI initiatives, NPR report writing, and tool development should be considered.
	We have initial training for new project implementations, but ongoing training is not consistent. Managers need training on existing tools as well as new tools.
	I am not sure that everyone in the organization applies the same definition to BI, at least in the past, so it's difficult to quantify the past in answering some of these particular questions.
	#33 Ambiguous question. Don't know how to answer.
TDA	Many tools and reports are unavailable and/or little instruction as to how to get them.
	or if there is a data warehouse we are to be using, I am unaware of it
	We purchased data repository but have barely used it. There is a disconnect between clinical intelligence and IT - I am concerned about data reconciliation and validation. We have at this point not developed consistent dashboards or menus where end users can easily find information
	Backup data center, data warehouse and consolidation of I.T. rings within the system to a single platform is underway and will be completed in the next 3 years.
	I am in meetings where the data warehouse is a great desired capability, but I hear that IT is dragging its feet. I do not know what the long term plan of the data warehouse is, so I answer as positively as I can. Then I ask IT and don't get answers either. Data is stored inconsistently in *Vendor A*, as evidenced during discussions about Computer Assisted Coding and Meaningful Use.
	The above is probably the plan, but is not there yet.
TDQ	Automation of processes would help eliminate data "bias"
	I am on several committees/teleconference that include others from the system. Much of the conversation is that we are not comparing apples to apples so that data cannot be used. Each facility files data and pulls data differently.
	For certain key metrics we do have a good standardized process for capturing and reporting data - such as the CMS quality indicators and meaningful use measures. Other data is not consistent and we have multiple report writers who may or may not be validating and reconciling the data.
	I believe it is getting better, but still not sure it is the same across the organization.
	The importance of standardization is becoming more apparent and people are becoming more open to that approach / need. Question #48 is yes, as long as this question is asked and verified when the data is being collected.
	#48 Standardization in a heterogeneous system is undesirable. Divergent local standards are appropriate.
	Often data provided down the steps is too old to be useful.
HCA	While there are several "lists" of reports available, description or function of reports are lacking. Would be beneficial to see sample reports to know which ones to request.

	There are standard data elements captured for administrative and financial metrics, which are used to improve processes. We do try to use *Vendor A* integrated solutions, which minimizes duplicate data entry.
	#53 Strongly disagree with first half of statement but strongly agree with second half of statement so I am confused on how to score.
HCC	Electronic data collection would be beneficial from a time and resource consumption perspective.
	Pay for performance has helped provide consistency throughout the organization
	Certain clinical performance indicators are consistent and reviewed regularly with process improvement activities tied to them. We try to use integrated *Vendor A* applications to minimize duplication, but there is still redundant data captured for various reasons.
	#59 Disagree with first half of question but agree with second half so confused on how to score question.
HCI	There is opportunity to report these items together, more clinical data is needed.
	I feel that our organization continues to look at data in silos instead of what is described here
	We do have processes in place to review integration and try to use integrated systems wherever possible. Administrative, financial and clinical data are all reported as part of process improvement, but we have not consistently implemented dashboards
	Much of this is a work in progress. We are getting better, but there is a long ways to go.
	I think we are just on the cusp of this section on integrating financial and clinical data
HCE	I believe another opportunity to increase data evaluation to determine services better needed to serve the patient population. Could be a "key" strategy to the development of prevention programs.
	We use industry standards such as HL7 to integrate external sources, but most require mapping of dictionaries instead of consistently using industry standard nomenclature. We have some health information exchanges started (Iowa, Nebraska, MN) but they are not consistent and require users to access yet another system to find patient data.
	External sources of SNOMED and LOINC are gaps in our EMR data store