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Applicability of Business Intelligence in Electronic Health Record

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Abstract

Clinical datasets provide an excellent environment in which combined analyses of both structured and unstructured datasets can prove fruitful and useful. With an increasing need to deploy Electronic Health Record (EHR) and Electronic Medical Record (EMR), there is also a corresponding need to apply data mining technologies to extract quality data and inference rules from the information stored in those electronic records so as to provide real-time decision supports and evidence-based practice to clinicians and healthcare providers. Business Intelligence (BI) has emerged as a technology that has the potential to operationalize the repository content of EHR in supporting evidence-based practice and improving the quality of healthcare delivery. In this paper, a literature review was used to explore the key benefits, challenges, and obstacles of incorporating the BI technology into EHR so as to improve the quality and safety of healthcare delivery.

Keywords: Business Intelligence; Electronic Health Record; Clinical Datasets; Healthcare Delivery

1. Introduction

The concept of *Business Intelligence* has garnered massive attention amongst healthcare providers and healthcare IT professionals as to its applicability in Electronic Health Record (EHR). According to Bhatnagar [1], Business Intelligence (BI) simply refers to the "tools an organization uses to gain a greater understanding of operations, markets, and competition" (p. 34). In other words, BI is used as a collective term to describe data analysis tools [2,3]. BI encompasses a broad category of methodologies, applications, and technologies for collecting, storing, manipulating, analyzing, and providing access to data to help enterprise users make better and faster business decisions [4,5,6,7]. BI has emerged as a technology that has the potential to operationalize the repository content of EHR in supporting evidence-based practice and improving the quality of healthcare

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delivery. The fact that the EHR contains massive clinical datasets about patients makes it a good repository for applying BI technology, thereby, maximizing the logic and inference rules emanating from the EHR.

Healthcare providers stand to gain enormously from the use of BI, as the technology hold larger promise in facilitating the adoption of the EHR as well as providing enough guidance to decision-makers from participating healthcare providers [8]. The capabilities of the BI technology have made it a force to be reckoned with when developing standards for EHR systems. However, the applicability and usability of BI tools in EHR remains elusive when it comes to the broader adoption of EHR. The purpose of this research study was to conduct a literature review to explore the applicability of BI in EHR. The first part of the paper gives an overview of the BI technology and EHR. In the second part, the focus is on BI and clinical datasets. The third part focuses on the key benefits, challenges, and technical barriers for incorporating the BI technology into EHR.

2. Methodology

A literature review, based on research articles from 2002 to 2012, was used to explore the applicability of BI in EHR. The methodology involved a review of relevant publications, found and accessed with the help of ProQuest and EBSCOhost databases. Additional sources were retrieved using the SAGE Journals Online, ScienceDirect, PubMed Central, Google Scholar, and ACM digital libraries. The targeted search terms consisted of the combination of keywords and/or phrases including: (a) business intelligence; (b) electronic health record, (c) clinical datasets, (d) business intelligence AND electronic health record, (e) business intelligence AND EHR, and (f) business intelligence AND electronic health record OR clinical datasets.

Overall, 376 articles were retrieved and 28 of them were reviewed in full. Findings from the reviewed papers were synthesized, paraphrased, and categorized under six broad themes: *Overview of Business Intelligence, Overview of an Electronic Health Record; BI and Clinical Datasets, Key Benefits of BI Technology, Key Challenges and Obstacles,* and *Conclusion.* Studies were included in the analysis if they reported on Business Intelligence and EHR.

3. Overview of Business Intelligence

Business Intelligence (BI) is a very popular topic in the field of data mining and knowledge discovery from databases (KDD). The BI technology is important because it provides applicable technologies to *operationalize* data warehouses, thereby, providing strategic intelligence and/or business logic to support the decision-making process of any given organization or industry. BI has become an important product in the IT industry because of lack of efficient data mining tools to support unstructured datasets. The traditional data mining tools are easily applicable to structured datasets, but have limitations with unstructured datasets [2,4]. BI works very well with both structured and unstructured datasets [2,4].

The definition of BI intelligence varies amongst researchers [9]. BI system may be defined as "an integrated set of tools, technologies and programmed products that are used to collect, integrate, analyse and make data available" [10, p. 4]. BI systems are regularly referred to as the successor to "decision support systems" and most often facilitate various kinds of enterprise reporting tools [4]. BI transforms information into knowledge and has the capability of "putting the right information into the hands of the right user at the right time to support the decision-making process" [10, p. 4].

The BI technology includes several software applications for extraction, transformation and loading (ETL), data warehousing, database query and reporting, multidimensional/online analytical processing (OLAP) data analysis, and data mining and visualization [9]. The four major components of BI constitute data warehouse, data sources, data mart, and query and reporting tools [4,9]. BI tools are widely used as middleware between transactional applications and decision support applications [9]. Specifically, BI technologies are used to shorten the time lag between data acquisition and decision making [5].

In the context of health informatics, BI is very useful and is seen as a new frontier of data mining [11,12]. BI technology platforms are gaining popularity in the healthcare domain because of their ability to "help management make better decisions in the exceedingly complex and ever changing business environment, to out-think the competition, to run the business in the most efficient way, to truly understand their customer base, and to deliver individualized products and services" [4, p. 2]. More specifically, BI offers the potential for healthcare organizations and providers to "effectively manage and leverage their data to improve financial and operational performance and the quality of patient care" [8, p. 68]. Moreover, the use of the BI technology in EHR enables healthcare providers to obtain the required clinical information efficiently and easily [13].

4. Overview of an Electronic Health Record

Electronic Health Record (EHR) is a "repository of information regarding the health status of a subject of care in computer processable form, stored and transmitted securely, and accessible by multiple authorized users" [14, p. 2]. This definition of the EHR emphasizes on three key components of the EHR: repository, secure storage and exchange of clinical information, and authorized accessibility. These three components of the EHR are very important when it comes to the adoption of EHR in clinical practice. EHR has the capability to provide "caregivers with all relevant information about every patient; encourage the sharing of medical knowledge through computer-assisted clinical decision support; facilitate computerized order entry among providers for tests, medicine, and procedures; and ensure secure, private, interoperable exchange of health information" [15, p. 36] among healthcare providers.

EHR is not an Electronic Medical Record (EMR), which in itself refers to a computerized medical record for collecting, storing, sharing, and displaying patient information [16]. EHR has proven to be a valuable system in supporting healthcare delivery. Watkins et al. [17] emphasized this importance by asserting that EHR is a "necessary means to improving patient safety, quality, and evidence-based practice" (p. 321). EHR is developed using interoperable standards to support the standardized capturing, storing, and retrieving of both structured and unstructured clinical datasets [17,18]. Recognizing the fact that the healthcare organizations operate in a dynamic environment, Watkins et al. [17] noted that the standardization of healthcare data using interoperable healthcare information systems such as the EHR will provide the foundation for future research and the increasingly vital quality and regulatory reporting.

EHR has emerged as an integrated healthcare information system that provides consistency of data and is necessary to serve patient-centered care, where healthcare information exists with many providers [17]. The fact that the EHR is a repository makes it a good candidate in which data mining algorithms can be applied to extract quality data from the EHR. The use of BI in EHR has the potential to operationalize the EHR repository in supporting evidence-based practice and improving the quality and safety healthcare delivery.

5. BI and Clinical Datasets

Clinical datasets provides an excellent environment in which combined analyses of both structured and unstructured datasets can prove fruitful and useful [3]. Applying BI technologies on clinical datasets has many benefits in improving the quality and safety of healthcare delivery. With an increasing need to deploy Electronic Health Records (EHR) and Electronic Medical Record (EMR), there is also a corresponding need to apply data mining technologies to extract quality data and inference rules from the information stored in those electronic records so as to provide real-time decision supports to clinicians and healthcare providers. Most clinical datasets are not structured and applying BI technologies ensure quality data extractions and analysis.

Clinical decision support systems are already equipped with inference rules or logics to assist clinicians and healthcare providers at the point of care. The quality of advices emanating from clinical decision support systems

is determined by the quality of data mining technologies used. Hence, if the business logics and/or inference rules are flawed, then they could introduce machine-related errors that will lead to misdiagnosis and wrong medications [19]. This is why it is important that the BI technology is used and applied appropriately on clinical datasets to support quality data extractions and analysis. The pervasive nature of the BI technology does not guarantee that the.

6. Key Benefits of BI Technology

There are several key benefits for integrating the BI technology with the EHR. The benefits of the BI technology can be primarily "identified in the form of the increased autonomy and flexibility of users, when it comes to creating reports, quick and simple analyses, improved decision support and operational efficiency, as well as a range of new analytical functions" [13, p. 116]. In measuring the benefits of BI technology, Hocevar and Jaklic [13] found that users of the BI technology solution identified very specific benefits including "ease of use, time-saving, improved decision support, flexibility, and positive reactions of customers due to faster responses" (p. 116). These properties of the BI technology make it attractive to many healthcare providers and healthcare IT professionals.

Many healthcare information systems such as the EHR and EMR possess a wealth of untapped strategic and clinical information that are of high value in the clinical decision-making process [17,18,20]. Applying BI technology to the repository content of the EHR will enable healthcare providers to extract quality and meaningful information that will facilitate real-time decision supports, evidence-based practice, and improve patient outcomes. The extracted data from the repository of the EHR could be used to help focus scarce resources and accelerate necessary change in the healthcare industry [20].

Integrating BI with the EHR will require, at the minimum, the availability of clinical data warehouse, quality data sources, and/or query and reporting tools. This minimum requirement is necessary to guarantee satisfaction of the BI tools usage. In a study conducted to assess the capability of a custom-built business intelligence tool, involving Crystal Reports XI™ and ASP.NET technologies, Jung et al. [21] found that the integration of the tool with the Longitudinal Medical Record (LMR) allowed clinicians to run quality reports on demand to help assess outcomes for patient care and for improving their documentation into the LMR.

The integration of the BI technology with the EHR will also offer many advantages to caregivers in clinical practice. For example, Kudyba and Rader [7] noted that integrating the BI technology with the EHR will afford the "ability to generate structured information on demand that can highlight where problem areas are such as what patients need to be targeted for specific evaluations while admitted to a facility given particular symptoms" (p. 430). Analysis of large sets of patient data is necessary to perform health protection surveillance, epidemiological studies and other statistical medical research needed to improve the quality of healthcare delivery and support evidence-based practice [15,22]. Secondary uses of health data is also facilitated with the application of BI technology on EHR [23,24].

7. Key Challenges and Obstacles

Several challenges and obstacles affect the appropriate integration of the BI technology with the EHR [7]. In a study conducted to determine the critical success factors of BI systems implementation, Yeoh and Koronios [25] noted that "non-technical factors, including organisational and process-related factors, are more influential and important than technological and data-related factors" (p. 74). Yeoh and Koronios [25] also found evidence that the contextual issues of the critical success factors of the BI technology are quite different from the implementation of other systems. This, therefore, means that achieving successful implementation of the BI technology in EHR is not an easy undertaking. It is difficult to integrate the BI technology with the EHR without giving careful consideration to the relevant contextual issues related to the EHR.

One of the prominent obstacles in implementing the BI technology in EHR is that data roles and governance are not adequately addressed in the EHR [8,18]. According to Glaser and Stone [8], data governance is one of the most significant contributors to the effective adoption of BI technology. Establishing data governance involves "the creation and management of the organizational structures, policies, and processes needed to define, control, and ensure the quality of data" [8, p. 69]. Through the data governance process, healthcare providers can best determine what types of analyses to focus on next as well as clearly define who their data stewards are and what responsibilities they hold [8]. It is in this regard that Glaser and Stone [8] noted that "solid governance and roles are essential, particularly at the start of a BI undertaking" (p. 72).

Beyond the problems associated with data roles and governance, there are also issues with data architecture such as data integrity, data semantics, and data security [26]. Jordan and Ellen [26] found that all the problems inherited from data architecture also impact the BI technology. Lack of properly defined data architecture will ultimately cause problems for the successful implementation of the BI technology in EHR. Glaser and Stone [8] correctly noted that high-quality data are of greater organizational value than state-of-the-art analytic software such as the BI technology. Follen et al. [27] also highlighted the importance of data integrity by asserting that maintenance of the validity and confidentiality of data is critical in ensuring the adoption of the EHR.

All of the above challenges coupled with the increasing resistance to the adoption of EHR in hospitals by medical practitioners often inhibit the broad utilization of the BI technology in the EHR. Even though several challenges are facing the adoption of the BI, many studies from the literature have suggested the need to use BI technology in EHR [3,4,8,20]. This need is of great necessity in the healthcare industry to ensure that clinical datasets are operationalized to support evidence-based practice and decision-making process of healthcare providers.

8. Conclusion

This paper has explored the importance of integrating the BI technology with the EHR. The research has the potential to benefit healthcare providers and stakeholders in determining the applicability of BI technology in integrated healthcare information systems. Even though several challenges are facing the implementation of BI technology in the EHR in clinical practice, the BI platforms are increasingly becoming more widespread and sophisticated as many corporate organizations continue to integrate BI with records management solutions [4]. Chaudhuri et al. [5] noted that it is "difficult to find a successful enterprise that has not leveraged BI technology for their business" (p. 91). It is, therefore, very important that healthcare providers and IT vendors become aware of the wealth of information contained in the EHR and take full advantage of the BI technology to assist them in the knowledge discovery process. Healthcare providers can use the BI technology as an investment strategy to focus on maximizing evidence-based practice.

The BI technology also serves as an e-discovery framework assisting healthcare providers to assess the information potential of both structured and unstructured datasets contained in the repository of EHR [3,4,25]. The increasing use of the BI technology demands further research to investigate its appropriate use in the healthcare industry. Further research and development of the BI technology should focus on bridging the gap that exists between academia and practitioners by investigating the critical success factors influencing successful implementation of BI systems in integrated healthcare information systems.

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