

Preface

INTRODUCTION

The use of Information and Communication Technologies are increasingly occupying an important place in society. The health sector is a particular case, as these Technologies can provide complete and reliable information for healthcare professionals, allowing support their clinical and administrative decisions and consequently decreasing medical errors.

Business Intelligence (BI) is a very popular topic. Scientific business intelligence community has more supporters. BI belongs to the most important current issues. It is related with the so-called democratization of information access when decisions are now based on consistent reasoning process instead of management feelings. This book is a collection of fifteen chapters. It makes a special attention on implementation of BI solutions processes and best practices in hospitals. The problem-solving process is seen with an intelligent vision.

In hospitals, in the clinical domain, the first step to solve problems on the ground is to solve interoperability issues between information systems. The second step is the development of electronic health records. Business Intelligence is the final step. In this book, ETL solutions are presented, data warehouse based on new schema solutions are proposed, BI solutions oriented to monitoring and reporting are addressed and issues related to knowledge discovery using data mining or soft computing are studied. The Knowledge Discovery in Database is a set of ongoing activities that enable the extraction of useful knowledge. The main goal is to discover useful, valid, relevant and new knowledge about a particular activity through algorithms, taking into account the magnitudes of data increasing (Goebel, Siekmann, & Wahlster, 2010). An attempt has been made in order to present valid and sound solutions to particular problems, mostly in real or critical world.

This publication aims to disseminate the Biomedical Informatics concepts, namely the use of Business Intelligence and its newest applications, to the scientific community. Consequently, it may inspire researchers to develop new solutions to

healthcare organizations in order to improve the quality of medical care and the patients' quality of life.

BIOMEDICAL INFORMATICS

Biomedical Informatics is an area that is spreading exponentially among several healthcare organizations. This phenomenon is happening due to the need that exists in these organizations to improve the quality of the healthcare. The Biomedical Informatics is fully capable to accomplish this mission. Issues as the BI in healthcare, Clinical Decision Support Systems (CDSS) and the information management are not only reducing the amount of paper in health organizations, but also reducing the occurrence of clinical and administrative errors. The implementation of BI tools in healthcare organizations help the managers and the healthcare professionals in the decision making process. The analysis of data provides relevant information about the activities and processes that happen inside the organization and this information can be essential to the patient diagnosis and problem solving.

BUSINESS INTELLIGENCE

The term Business Intelligence (BI) was introduced by Howard Dresner in 1989. BI is the set of concepts and methods used to improve the decision making process in an organization, using computational methods and tools (Power, 2008; Ghanzanfari, Jafari, & Rouhani 2011). It also includes best practices that transform data into knowledge and enable analysis of information to improve and optimize decisions and performance.

Thus, it promotes a more reasoned decision making and, consequently, better results for the organization (Power, 2008; Prvedllo, Andriole, Hanson, et al., 2010; Glaser, & Stone, 2008). So, the system transforms data into information, that later can generate strategic and relevant knowledge to support the decision making process, allowing better performance (Bonney, 2013; Popovič, Hackney, & Coelho, et al., 2012). BI systems have the ability to timely provide the correct information needed to support the decision making process, resulting in a competitive advantage for the organization.

According to Popovič et al. (Popovič, Hackney, & Coelho, et al., 2012), the implementation of BI systems can contribute to improve the quality of the information used by the organization, through: a faster access; the easiness in querying and exploring data; and the improvements on data consistency as a result of the integration processes performed before data storage on the Data Warehouse.

APPLYING BUSINESS INTELLIGENCE TO CLINICAL AND HEALTHCARE ORGANIZATIONS

The healthcare units have been adopting several informatics and technological solutions in order to contribute to a better functioning of the institutions and to improve the quality of the services provided. However, a healthcare organization is an environment with a large amount of information that is indispensable for the decision making process made by the healthcare professionals. It is necessary to ensure that all this information is available when it is needed and it is fundamental that it be interpreted correctly to avoid errors that can jeopardize the life of a human being. The solution is accomplished through the concept of semantic interoperability that represents the ability of systems to communicate with each other without the change of the meaning of the information, in other words ensure that the information is interpreted likewise by all stakeholders (systems and professionals). Thus, an important procedure to do in healthcare organizations is the semantic mapping of clinical data. Today there are some standard terminologies to represent clinical content, the SNOMED-CT (Systematized Nomenclature of MEDicine - Clinical Terms) is an example. Nevertheless, the semantic interoperability of the Health Information Systems (HIS) is only possible if the clinical data models, like openEHR archetypes, are according the standard terminologies.

Interoperability in HIS is increasingly a requirement rather than an option. Standards and technologies, such as multi-agent systems, have proven to be powerful tools in interoperability issues. In the last few years, we have worked on developing the Agency for Integration, Diffusion and Archive of Medical Information (AIDA), which is an intelligent, agent-based platform to ensure interoperability in healthcare units (Peixoto, Santos, Abelha, et al., 2012). It is increasingly important to ensure the high availability and reliability of systems. The functions provided by the systems that treat interoperability cannot fail and monitoring and controlling intelligent agents is a crucial tool to anticipate problems in HIS. Healthcare systems evolve by adopting more features and solving new problems (Caroso, Marins, Portela, 2014). Interoperability is the first step to provide electronic health records to HIS, and the so-called Paper Free Hospital is not possible without interoperability and Electronic Health Record (EHR). (Salazar, Duarte, Pereira, 2013). With the adoption of the EHR it was possible to acquire the versatility of a device capable of storing a vast sum of data. This was the great advantage obtain with the transition of Paper Clinical Process (PCP) to EHR. The data legibility, the continuous data processing, the ability to detect errors or releasing alarms concerning eventual pathological anomalies can also be considered as positives features acquired with the implementation of EHR. With the inclusion of this advantages, the patient assistance has become more effective, faster and with better quality. Information technology has great potential for

transforming the health care system, improving quality of care. With the increasing expansion of health information systems, the Electronic Health Record (EHR) has become one of the finest sources for clinical information aggregators in the context of digital health. The EHR is a core part of a hospital information system, as well as a service on duty of the patient to improve the treatment of patients. It can be considered as a longitudinal electronic record of patient health information, for example vital signs, medical history or laboratory data, generated by one or more encounters in any care delivery setting. The next step is applying business intelligence to clinical and healthcare organizations.

The implementation of BI in clinical and healthcare organizations is an efficient and adequate method to integrate and explore the clinical data collected by healthcare institutions. Data are collected and stored in databases, and are also used for decision support. BI systems process data, explore them, extract information and discover knowledge. Knowledge representation and reasoning techniques must be capable of covering every possible instance by considering incomplete, contradictory, and even unknown data (Neves, Martins, Vilhena, et al., 2015). These techniques must be very versatile and capable of covering almost every possible instance. This new approach can revolutionize prediction tools in all its variants, making it more complete than the existing methodologies and tools available (Neves, Guimarães, Gomes, 2015). Managing information quality is a continual process but many times, and in particular in clinical and healthcare organizations, it is crucial to know how to take decisions based on incomplete information.

This knowledge can be very relevant to identify, analyse and monitor the activities and processes that happen inside the healthcare institution. With BI, it is possible to discover problems and improvement opportunities in the healthcare environment. Therefore, the implementation of BI systems in healthcare institutions may help to improve the quality and safety of the delivered care; improve the efficiency and the financial performance of the healthcare institution; promote the implementation of evidence-based practices; promote a more efficient resource utilization. These improvements and advantages can occur because BI helps managers and healthcare professionals to make better and faster decisions, through data analysis about the activities and practices of the healthcare unit (Prvedllo, Andriole, Hanson, et. al.; 2010; Foshay & Kuziemy, 2014). Moreover, the healthcare environment is very complex and dynamic. BI tools are essential to support the decision making process in the healthcare units, providing to the patients better and more affordable healthcare services. It can then be seen as a set of techniques and methods, with the ability to cope with practical solutions, in the same way that humans deal with these solutions either by common sense or intelligence.

BI tools are capable of working with healthcare data in an efficient manner, to generate real-time information and knowledge and this is the reason why they are

very attractive to the healthcare sector. The principal benefits of BI technology are the saving of time in the access and in the analysis of data, the flexibility and the improvement in decision making by using information driven from real data. However, a BI system must be able to perform two fundamental tasks: integrate huge amounts of data coming from several different heterogeneous sources and provide the analytical tools for these data analysis. Thus there is a need to build BI tools adapted to the medical field and to the specificity of data that exists in these organizations.

ORGANIZATION OF THE BOOK

The book is organized into fifteen chapters. A brief description of each of the chapters follows:

Chapter 1 reviews issues surrounding interoperability in healthcare. Interoperability is the first step towards building the electronic health record and business intelligence systems, both in the administrative domain as the clinical one. The chapter presents a set of practical case studies carried out in a Portuguese hospital, in particular the use of an interoperability platform supported by intelligent agents.

Chapter 2 establishes the need of developing knowledge representation and reasoning techniques capable of covering every possible instance by considering incomplete, contradictory, and even unknown data. A new paradigm of knowledge representation and reasoning enables the use of the normalized values of the interval boundaries and their degree of confidence values, as inputs to Neural Networks. The output translates the risk prediction for nosocomial infection and the confidence that one has on such a happening.

Chapter 3 addresses the issue of creating a decision support system that allows the transformation of information into knowledge, giving usability to the stored data. A particular case of voluntary interruption of pregnancy study by means of business intelligence is presented in a healthcare unit. The benefits of such an implementation concern are discussed.

Chapter 4 analyses clinical recommendation systems as clinical decision support systems used to help health professionals to take evidence-based decisions. The chapter presents an overview of the clinical recommendation system for obstetric triage, the model developed and the main results achieved.

Chapter 5 proposes contributions to generate the hospital data warehouse schema, an assistant system to facilitate the collection of healthcare staff requirements, a new schema integration methodology to ensure the automatic merging of the schemas and an application of the new approach to build the hospital data warehouse.

Chapter 6 presents the digital concepts under people well-being research through the demonstration of research examples and applications. Health, comfort and well-being are points of concern in smart cities. On the other hand, healthcare organizations have a potential access to individual and grouped electronic records and aggregated records provide a global picture of populations, intervention and where effort should be conducted in order to help public health.

Chapter 7 deploys a systematic literature review methodology not only to explore the key benefits and technical challenges of Healthcare Information Systems (HIS), but also to discuss the optimization approaches to maximizing the use and adoption of HIS in healthcare delivery. The first part of the paper describes the systematic review methodology. In the second part, the focus is on the overview of the system and their associated key benefits and challenges in the healthcare domain. The third part focuses on the optimization techniques and approaches to maximizing the use and adoption of HIS to support effective and efficient healthcare delivery and translational research.

Chapter 8 addresses the problem of keeping a patient in a hospital in order to resolve health problems and the degree of confidence on such a happening despite the increasing of costs. The chapter presents the founding of a computational framework that uses knowledge representation and reasoning techniques to set the structure of the information and the associate inference mechanisms.

Chapter 9 discusses the importance of Electronic Health Records allowing the integration and standardization of clinical information. The problem is the duplication of information or the lack in information availability and reliability. Authors discuss semantic interoperability issues for clinical and business intelligence solutions, proposes SNOMED adoption and presents a case study.

Chapter 10 presents a business intelligence platform for predicting nosocomial infections by means of data mining. The platform supports healthcare professionals in their decisions, namely in planning infection prevention measures. The system acts as a CDSS capable of reducing nosocomial infections and the associated costs, improving healthcare and increasing patient's safety and well-being.

Chapter 11 presents a platform to evaluate the time prescription, which can afterwards be applied in the decision-making process. This platform enables the identification of measures to unravel the time differences that some physicians exhibit, in order to, subsequently, improve the whole process of electronic medical prescription.

Chapter 12 addresses a new methodology to prevent stroke accidents by using segmentation methods, which allows distinguishing and aggregating clusters of historical records, classification methods, such as artificial neural networks, capable of classifying a new record according to its distribution among the clusters.

A multi-agent case based reasoning system is also proposed to evaluate solutions based in a similar case.

Chapter 13 aims to explain the construction process of learning systems based on soft computing systems, in particular neural networks and genetic algorithms. These systems were implemented using R and Python programming languages, in order to compare results and to achieve the best solution and it was used Diabetes and Parkinson datasets with the purpose of identifying the carriers of these diseases.

Chapter 14 presents a multiplatform decision support tool in Neonatology and Paediatric Care for the daily tasks of paediatricians or even for education and training.

Chapter 15 presents principles to conclude that the real value of Business Intelligence systems lies in their use to support organizations to make better informed decisions that will lead to increased profitability, lowered costs, improved efficiency or whatever the goals of the organization might be. In healthcare institutions, efficiency is a main requisite that makes this tools crucial for a reliable system.

CONCLUSION

This book intends to contribute to the subject matter of BI, in particular in the healthcare sector, when applying to real world problems. The number of BI solutions implemented in hospitals is reduced. In many hospitals, the problem of the lack of semantic interoperability have not been resolved and the electronic health record is still in a late stage. The main aim of this publication is to present some case studies that demonstrate the applicability of BI solutions, pointing out benefits and best practices. The use of appropriate tools by health professionals, can help them to identify causes and more effective treatments focused on patient disease. This book aims to show the importance of developing systems capable of interacting with an intelligent environment system using hybrid methods. It also looks to discuss and address the difficulties and challenges that healthcare organizations have faced in implementing BI technologies and applications. Additionally, the book will explore the impact of such technologies in healthcare organizations.

The target audience is composed by Health Organizations, Hospitals, Health Professionals, Biomedical Engineers, Informatics Engineers, Researchers in the Biomedical Informatics, Artificial Intelligence and Medicine fields.

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REFERENCES

- Bonney, W. (2013). Applicability of business intelligence in electronic health record. *Procedia: Social and Behavioral Sciences*, 73, 257–262. doi:10.1016/j.sbspro.2013.02.050
- Cardoso, L., Marins, F., Portela, F., Santos, M., Abelha, A., & Machado, J. (2014). The Next Generation of Interoperability Agents in Healthcare. *International Journal of Environmental Research and Public Health*, 11(5), 5349–5371. doi:10.3390/ijerph110505349 PMID:24840351
- Foshay, N., & Kuziemy, C. (2014). Towards an implementation framework for business intelligence in healthcare. *International Journal of Information Management*, 34(1), 20–27. doi:10.1016/j.ijinfomgt.2013.09.003
- Ghazanfari, M., Jafari, M., & Rouhani, S. (2011). A tool to evaluate the business intelligence of enterprise systems. *Scientia Iranica*, 18(6), 1579–1590. doi:10.1016/j.scient.2011.11.011
- Glaser, J., & Stone, J. (2008). Effective use of business intelligence. *Healthcare Financial Management*, 62(2), 68–72. PMID:18309596
- Goebel, R. Siekmann, J., Wahlster, W. (Eds), (2010). Advances in Knowledge Discovery and Data Mining, Lecture Notes in Computer Science (Vol. 6118). Springer.
- Neves, J., Guimarães, T., Gomes, S., Vicente, H., Santos, M., Neves, J., & Novais, P. et al. (2015). Logic Programming and Artificial Neural Networks in Breast Cancer Detection. In I. Rojas, G. Joya, & A. Catala (Eds.), *Lecture Notes in Computer Science: Vol. 9095. Advances in Computational Intelligence* (pp. 211–224). doi:10.1007/978-3-319-19222-2_18
- Neves, J., Martins, M. R., Vilhena, J., Neves, J., Gomes, S., Abelha, A., & Vicente, H. et al. (2015). A Soft Computing Approach to Kidney Diseases Evaluation. *Journal of Medical Systems*, 39(10), 131. doi:10.1007/s10916-015-0313-4 PMID:26310948
- Peixoto, H., Santos, M., Abelha, A., & Machado, J. (2012). Intelligence in Interoperability with AIDA. Proceedings of the 20th International Symposium on Methodologies for Intelligent Systems, 2012 World Intelligence Congress, Macau, LNCS (Vol. 7661). Springer. doi:10.1007/978-3-642-34624-8_31
- Popovič, A., Hackney, R., Coelho, P. S., & Jaklič, J. (2012). Towards business Intelligence systems success: Effects of maturity and culture on analytical decision making. *Decision Support Systems*, 54(1), 729–739. doi:10.1016/j.dss.2012.08.017

- Power, D. J. (2008). Understanding data-driven decision support systems. *Information Systems Management*, 25(2), 149–154. doi:10.1080/10580530801941124
- Prevedello, L. M., Andriole, K. P., Hanson, R., Kelly, P., & Khorasani, R. (2010). Business intelligence tools for radiology: Creating a prototype using open-source tools. *Journal of Digital Imaging*, 23(2), 133–141. doi:10.1007/s10278-008-9167-3 PMID:19011943
- Salazar, M., Duarte, J., Pereira, R., Portela, F., Santos, M., Abelha, A., & Machado, J. (2013). Step towards Paper Free Hospital through Electronic Health Record. In Á. Rocha, A. M. Correia, T. Wilson, & K. A. Stroetmann (Eds.), *Advances in Information Systems and Technologies, Advances in Intelligent Systems and Computing* (Vol. 206, pp. 685–694). Springer. doi:10.1007/978-3-642-36981-0_63

