How Do Business Analytics and Business Intelligence Contribute to Improving Care Efficiency?

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Abstract

The growth in volume, variety, and velocity of data has created new challenges and opportunities for healthcare contexts. Although Business Analytics (BA) technologies, techniques and tools are becoming recognised to improve the ability to analyse multi-spectral healthcare data, in and of themselves they are not sufficient to realise the full potential and benefits possible which can lead to optimal patient outcomes. In fact, it becomes a strategic necessity to develop a systematic and organising framework to apply BA technologies to a specific clinical context. Hence, this exploratory study is designed to investigate and thereby develop an appropriate organising framework and then a prototype to apply the benefits of the Business Analytics techniques to Healthcare contexts. The chosen clinical context is oncology and the study site is one of the largest private tertiary hospitals in Melbourne, Australia. Given the importance of cancer care, the cost of cancer treatments and the quantity and range of data elements that are generated during the care process, this case study is significant and important.

Keywords: Business Analytics (BA), Clinical Decision Making, Real-time Analytics, Evidence-based Decisions, Cancer Treatment, Oncology, Action Research Methodology.

1. Introduction

Although, healthcare organisations have a wealth of data accessible through several data sources, much of these data are incomplete or incorrect and thus often usable to assist in improving outcomes and quality care delivery.

Today, many healthcare organizations around the world, are challenged by pressure to reduce costs, improve coordination and outcomes, provide more with less and be more patient centric [6][21]. Contemporaneously, new approaches to healthcare delivery and healthcare services are increasing complexity and competition [12].

To address these challenges and thereby provide optimal patient care outcomes, the application of Business Analytics technologies, tools and techniques are recommended [10][7][13][14][17][18][21][22].

Succinctly, business analytics is the systematic use of data and related business insights developed through applied analytical disciplines (e.g. statistical, contextual, quantitative, predictive and cognitive) to drive fact-based decision making for planning, management, measurement and learning [5].

According to a recent IBM report in 2013, 54% of top performing healthcare organizations around the world use business analytics to guide strategy, 59% of these organizations perform product research and
sales and 65% of the use business analytics solutions for financial and marketing development [11].

Our findings to date, show a significant opportunity to leveraging the multi-spectral data collected through a strategic application of BA solutions to improve knowledge sharing between clinicians as well as between clinicians and patients [21, 22]. Also, there are lots of opportunities to reduce costs and to improve clinical risk detection and outcome predictions in order to enhance decision efficiency at healthcare contexts which will ultimately lead to optimal patient care outcomes. The research question is:

*How Does Business Analytics Contribute To Improve Care Efficiency At Healthcare Contexts?*

To fully investigate the benefits of leveraging BA in this fashion, the case of cancer care has been chosen.

Cancer is one of the most common diseases in today’s modern society both in the ambulatory and inpatient setting. Cancer treatment regimens are complex, have high risks associated with them and often have unwanted variances. One area within cancer treatment today that exemplifies these issues is in the prescribing and administering of complex chemotherapy protocols. Although part of drug prescribing generally, chemotherapy is much more complex than most other drug prescribing in terms of the intrinsic toxicity of the drugs, the complexity of the schedules of administration and the necessity for close monitoring. Additional differences from other prescribing are the role of specially trained chemotherapy nurses who actually administer most of the drugs and a very high level of pharmacy engagement.

Hence, the aim of this study is driving operational efficiencies, reducing costs and improving the quality of care through investigating the benefits of BA tools and techniques to enhance care efficiency at Healthcare contexts, in the case of cancer treatment. The primary objectives of this study include:

- Investigate the benefits of BA in order to improve the treatment and management of care: This will be achieved by supporting better, informed collaborative decision making which will in turn allow for more appropriate/successful treatment choices to be made.

- Investigate the benefits of BA in order to gain optimal understanding of the treatment process: This will be achieved by developing an initial repository for analysis and from this to discover and extract hidden knowledge (patterns and relationships) associated various treatments from historical data which will not only lead to a better understanding of critical and potentially confounding aspects to recovery but also facilitate more tailored and appropriate treatment regimens in the specific context.

  - Investigate the benefits of BA in order to explore preventative measures to reduce care side effects: This will be achieved by developing important KPIs (key performance indicators) as a set of metrics and then using these to design and develop more suitable dashboard to monitor patient’s conditions and also treatment processes in the case of cancer care.

  - Investigate the benefits of BA in order to fully realize the true potential of big data; data is key to developing a strong foundation for managing data quality with best-of-breed data quality tools to address incomplete or incorrect data and practices that can scale and be leveraged across the Hospital.

2. **Background**

Business Analytics comprises an integrated array of IT tools that allow users to transform data into informed actions [1, 2]. The critical functionality that all BI systems [3] share is the establishment of a logical, comprehensible interface between the human user and a central data repository, known as a data warehouse (figure 1).

By offering valid, comprehensive views of organizational data, BI tools help users to understand complex processes and relationships by means of easily assimilated, customized visual reports that help users to make timely and informed decisions, take actions that will improve performance, and understand how their actions affect the entire organization [4]

Data warehouses and BI technologies have been used in healthcare settings to improve workflow efficiency [5], monitor quality and improve outcomes [6], develop best practices [7], optimize insurance procedures [8], and uncover patterns of increased expenditures [9]. Many health systems are also using ‘scorecard’ [10] and ‘dashboard’ [11] methodologies and developing Web-based query and reporting tools
[11, 12] to optimize delivery of services as well as improve their own data warehouse projects [10].

Figure 1. Key functionalities of a business intelligence application in the healthcare environment (Adapted from [3])

2.1. Business Analytics

Business analytics is commonly viewed from three major perspectives: descriptive, predictive, and prescriptive (Figure 2). Most businesses start with descriptive analytics [13]- the use of data to understand past and current business performance and make informed decisions. Descriptive analytics are the most commonly used and most well understood type of analytics. These techniques categorize, characterize, consolidate, and classify data to convert it into useful information for the purposes of understanding and analysing business performance. Descriptive analytics summarize data into meaningful charts and reports, for example, about budgets, sales, revenues, or cost. They allow managers to obtain standard and customized reports, and drill down into the data and to make queries to understand the impact of an advertising campaign, for example, review business performance to find problems or areas of opportunity, and identify patterns and trends in data. Typical questions that descriptive analytics help answer are: How much did we sell in each region? What was our revenue and profit last quarter? How many and what types of complaints did we resolve? Which factory has the lowest productivity? Descriptive analytics also help companies to classify customers into different segments, which enable them to develop specific marketing campaigns and advertising strategies.

Predictive analytics analyse past performance in an effort to predict the future by examining historical data, detecting patterns or relationships in these data, and then extrapolating these relationships forward in time. For example, a marketer might wish to predict the response of different customer segments to an advertising campaign, a commodities trader might wish to predict short-term movements in commodities prices, or a skiwear manufacturer might want to predict next season’s demand for skiwear of a specific colour and size. Predictive analytics can predict risk and finds relationships in data not readily apparent with traditional analyses. Using advanced techniques, predictive analytics can help to detect hidden patterns in large quantities of data to segment and group data into coherent sets in order to predict behaviour and detect trends. For instance, a bank manager might want to identify the most profitable customers or predict the chances that a loan applicant will default, or alert a credit card customer to a potential fraudulent charge. Predictive analytics helps to answer questions such as: What will happen if demand falls by 10 percent or if supplier prices go up five percent? What do we expect to pay for fuel over the next several months? What is the risk of losing money in a new business venture?

Prescriptive analytics uses optimization to identify the best alternatives to minimize or maximize some objective. Prescriptive analytics is used in many areas of business, including operations, marketing, and finance.

Figure 2. One perspective on business analytics (Adapted from [13])

The mathematical and statistical techniques of predictive analytics can also be combined with optimization to make decisions that take into account the uncertainty in the data. Prescriptive analytics addresses questions like: How much should we produce to maximize profit? What is the best way of shipping goods from our factories to minimize costs? Should we change our plans if a natural disaster closes a supplier’s factory and if so, by how much?

Figure 3, presents a review of BI and BA evolution, Applications, and Emerging Research.
2.2. BA Benefits to Healthcare

Much like the big data opportunities facing the e-commerce and SandT communities, the health community is facing a tsunami of health- and healthcare-related content generated from numerous patient care points of contact, sophisticated medical instruments, and web-based health communities. Two main sources of health big data are genomics-driven big data (genotyping, gene expression, sequencing data) and payer–provider big data (electronic health records, insurance records, pharmacy prescription, patient feedback and responses) [15]. The expected raw sequencing data from each person is approximately four terabytes. From the payer–provider side, a data matrix might have hundreds of thousands of patients with many records and parameters (demographics, medications, outcomes) collected over a long period of time. Extracting knowledge from health big data poses significant research and practical challenges, especially considering the HIPAA (Health Insurance Portability and Accountability Act) and IRB (Institutional Review Board) requirements for building a privacy-preserving and trustworthy health infrastructure and conducting ethical health-related research [15].

Health big data analytics, in general, lags behind e-commerce BI and A applications because it has rarely taken advantage of scalable analytical methods or computational platforms [15].

Over the past decade, electronic health records (EHR) have been widely adopted in hospitals and clinics worldwide [19]. Significant clinical knowledge and a deeper understanding of patient disease patterns can be gleaned from such collections [20].

Hanauer et al. [19], for example, used large-scale, longitudinal EHR to research associations in medical diagnoses and consider temporal relations between events to better elucidate patterns of disease progression [16]. Lin et al. used symptom–disease–treatment (SDT) association rule mining on a comprehensive EHR of approximately 2.1 million records from a major hospital [17].

In addition to EHR, health social media sites such as Daily Strength and Patients LikeMe provide unique research opportunities in healthcare decision support and patient empowerment [13], especially for chronic diseases such as diabetes, Parkinson’s, Alzheimer’s, and cancer. Association rule mining and clustering, health social media monitoring and analysis, health text analytics, health ontologies, patient network analysis, and adverse drug side-effect analysis are promising areas of research in health-related BI and BA [21].

2.3. Possible Areas to Apply BA in Cancer Care in this study

Due to the importance of prescription and administration of complex chemotherapy protocols, using BA techniques should be effective to improve the care efficiency and outcomes. Hence, outcomes of this project will also be used to design and develop a robust application using business analytics techniques towards effective cancer chemotherapy. Considering the current project, possible areas to apply business analytics techniques in this study are:

- **Predicting adverse drug reactions**

  Adverse drug reaction is an appreciably harmful or unpleasant reaction, resulting from an intervention related to the use of a medicinal product that should be managed through withdrawal of the drug if possible and specific treatment of its effects as soon as possible [1].

  Adverse drug reactions for cancers are classified by WHO into six types (with mnemonics): dose-related (Augmented), non-dose-related (Bizarre), dose-related and time-related (Chronic), time-related (Delayed), withdrawal (End of use), and failure of therapy (Failure) [2].

  Hence, detecting and monitoring adverse drug reaction in these 6 categories and thus predicting future patients’ reactions to these particular drugs might be beneficial.

- **Predicting multidrug resistance**

  Multidrug resistance is the most widely exploited phenomenon by which cancer eludes chemotherapy
Also, it is the leading cause of chemotherapeutic failure in the treatment of cancer [4].

Recently, nanotechnology has emerged as a powerful tool in addressing some of the barriers to drug delivery; however, it is unclear whether drugs can be delivered by nano-technologic approaches or not [3]. Hence, designing a solution to predict the multidrug resistance at earliest stage of treatment can be efficient for future improvement in this area.

3. Research Design and Method

In this exploratory study a qualitative approach using a single clinical context (cancer care) will be examined across three study sites at one of the biggest private hospitals in Melbourne, Australia. The study will involve 3 key phases as follows Phase 1: benchmarking and assessment of the current state Phase 2 design of the organising framework and then the development of a prototype solution and Phase 3 testing the solution. Participants will include the study site based private physicians, oncology nurses, pharmacists and consumers of oncology data and information at the study site as well as executives. Participation is voluntary. Recruitment will be done via email to a) make the relevant individuals aware of the study and b) request their participation.

Established qualitative data collection techniques and analysis techniques will be used. Qualitative data will be collected through observation, database reviews, benchmarking, on-line survey and focus groups to capture current issues as well as participants’ requirements and feedback which will serve to form a needs assessment and thereby enable the design of the framework and prototype. Table 1 summarises the data collection process and also the available data collection systems at the three target sites across the Hospital.

Table 1: Data collection steps and process

<table>
<thead>
<tr>
<th>The data collection site</th>
<th>Participants</th>
<th>How the data will be collected?</th>
<th>Data Collection Systems or data sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>Private physicians, oncology nurses, pharmacists and consumers of oncology data and executives</td>
<td>On-line Survey Focus Group Database reviews Observation</td>
<td>- IPM</td>
</tr>
<tr>
<td>Site 2</td>
<td>Private physicians, oncology nurses, pharmacists and consumers of oncology data</td>
<td>On-line Survey Focus Group Database reviews</td>
<td>- IPM</td>
</tr>
<tr>
<td>Site 3</td>
<td>Private physicians, oncology nurses, pharmacists and consumers of oncology data</td>
<td>On-line Survey Focus Group Database reviews</td>
<td>- IPM</td>
</tr>
</tbody>
</table>

3.1. Study Methodology

The nature of this study is exploratory focusing on cancer care across the study site that is one of the biggest private hospitals in Melbourne, Australia. An Action Research Methodology will be applied to design and develop an appropriate strategy to adapt BA to this context as well as to develop a prototype solution.

Action research, presented in figure 4, is an interactive inquiry process that balances problem solving actions implemented in a collaborative context with data-driven collaborative analysis or research to understand underlying causes enabling future predictions about personal and organizational change [15].

3.2. Recruitment Strategy

Participation is voluntary. Recruitment will be done via email to request participation and to ensure the relevant individuals are aware of the study the participants’ information sheet will be supplied at this time. Submission of completed survey is used to assume consent for those individuals we shall be surveying while for those individuals in the focus groups signed consent form will be collected before the commencement of the focus group.
3.3. Data Collection Plan and Data Analysis

As the proposed study is one of the biggest private hospitals in Melbourne, Australia, the setting will include all hospital facilities that treat oncology patients with chemotherapy.

Participants/key informants will include private physicians, oncology nurses and pharmacists as well as consumers of oncology data and executives. Three data collection techniques (benchmarking, database reviews, online survey and focus group) as well as the data collection plan are summarised in the following table.

It is recommended that applicants seek statistical and/or peer review to discuss the study design and its statistical validity. Thematic analysis [8][16] will be used in conjunction with NVIVO or Dedoose to perform the qualitative analysis aspects of the data analysis. In addition, some descriptive statistical analysis including frequently analysis will also be used.

The focus group discussions will be transcribed and themes will then be identified from the transcripts. Specifically, the focus group main objectives include:

2) Evaluating and assessing the prototype by clinicians and also executives.

3) Identification of any ideal future state for the solution and how this might be addressed and what is required to realize this state.

4) Any other key points that are relevant and should be considered in the final solution.

Hence, findings from the focus group will be applied to the prototype in order to improve patients’ outcomes.

The findings from the thematic analysis will be used to assess the usability and acceptability of the prototype and also to further explore the specific benefits of the proposed solution. Based on the feedback from the focus group the final prototype will be tweaked.

As all data collection and analytical methods have limitations, collecting patients’ data in the case of cancer care has also some limitations especially given the high mutability of patients’ conditions during the oncology journey mutable. In this case, collecting longitudinal data are essential for drawing conclusions about changes occurring within the individual patients, but because they are observational rather than experimental, it is important to recognize that even longitudinal data are limited with respect to data access and integrity issues in the study site.

4. Discussion

Outcomes of this study are essential for the study site as it address issues regarding Big Data, and analytic capabilities so that raw data assets currently residing in various databases can be truly harnessed and then optimally utilised and leveraged to ensure superior clinical outcomes. Given the importance of oncology to the study site the results from this exploratory study can enable this hospital to further differentiate its operations in this clinical domain.

Finally, knowledge and understanding of the BA content and techniques regarding oncology contexts can also be leveraged to other clinical domains across the study site and then in the national level.

To date, realising the full potential of business analytics (BA) at healthcare contexts is significantly underutilised. BA can play a pivotal role to assist in designing and planning efficient policies and programs, improving service delivery and operations, enhancing sustainability, detecting and mitigating clinical and non-clinical risks and providing a means for measuring and evaluating critical organizational data.
Figure 5, succinctly presents the conceptual model which highlights the main components of a possible BA organising framework as well as highlighting key aspects of the proposed study.

We have been using an array of offline analytical platform such as RapidMiner and SPSS for the mining of data. Also big data platform like Hadoop will be used for large volume of data. We will create applications of analytics to build models able to predict risks in cancer treatment processes. Patients’ patterns captured through historical datasets may allow clinicians to make evidence-based clinical decision making in order to treat different types of cancer by comparing data from similar patients in the past with the current observed patient.

At this exploratory study it will be possible to develop an appropriate organising framework to apply the necessary BA technologies, tools and techniques in the specific context.

This is an essential first step to ensure that the BA assets current and future will be optimally and strategically used.

**Figure 5: Conceptual Model to present key aspects of the study**

Thus, a key benefit of this study for the study site is that it will enable the design and development of the most appropriate technology platform and rubrics for BA applications in clinical contexts in order to make more efficient, effective and analytical approaches to ensure a high quality of patient outcomes, care efficiency as well as a high patient experience. From this a secondary end point is the development of a prototype to demonstrate the bespoke uses of BA for the study case.

5. Conclusion

This research in progress has focused on cancer care across three study sites at one of the biggest private hospitals in Melbourne, as a single case study. An Action Research Methodology is applied to design and develop an appropriate strategy to adapt BA to this context as well as to develop a prototype solution.

At the conclusion of this study, it will be possible to develop an appropriate organising framework and a bespoke prototype to apply the necessary BA tools and techniques in the specific cancer treatment context. This is an essential first step to ensure that the BDA assets current and future will be optimally and strategically used.

Thus, a key benefit of this study is designing and developing the most appropriate BA application in cancer context in order to make more efficient, effective and analytical approaches to ensure a high quality of patient outcomes and care efficiency as well as a high patient experience, at Australian healthcare sectors.

**References:**


