A SWOT Analysis of Big Data in Healthcare

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Abstract: Nowadays, organizations in the most distinct sectors of activities, are generating enormous amounts of data, at high velocity and high variety. This phenomenon dictated a growing technological development, called big data, which is already recognized as one of the most important areas of the future of information. Due to this fact, organizations have been looking for new solutions to improve their services and take advantage of these new technologies. The reality in the healthcare industry is similar to the phenomenon described above. It is a sector where large amounts of data have been stored digitally and with enormous benefits from these new technologies. Despite this, there are very few health-related organizations making investments in big data and taking advantage of it. This article will address a SWOT analysis, more specifically the strengths, weaknesses, opportunities and threats of big data in healthcare in order to help organizations to evaluate its potential.

1 INTRODUCTION

Big data is a contemporary phenomenon, more and more electronic data are being generated in the world and will continue to increase. Due the smartphones, sensors that turn real-world phenomena into data, smart home appliances, computer systems and other internet of things systems that produce and stream huge amounts of different types of electronic data (Lee, 2017).

The development of big data also includes new ways of collecting, storing and processing information in order to make it available and useful. Beyond that, big data has raised the capability of data analysis and reasoning to unprecedented levels (Maciejewski, 2017). The digitization of information along computing power create powerful possibilities to convert information into knowledge that helps organizations achieve their goals (Murdoch & Detsky, 2013).

In the health sector, the reality is no different. Historically, this industry has also generated large amounts of data from record keeping, regulatory requirements and patient care (Raghupathi & Raghupathi, 2014). It's evident that within these amounts of data there is occult knowledge that can change a patient life or, who knows, the world. According to (BDV, 2016), extracting this knowledge is fastest, least costly and most effective path to improving population health. The potential of big data can impact positively technology, economic and society, boosting innovations and leading to the improvement of business models. However, the path to extract knowledge from big data brings challenges and it's important to understand them in order to be successful.

Having as motivation all the aspects mentioned above, the purpose of this article is to provide a SWOT analysis, which allows to evaluate the potential of big data in healthcare. Therefore, in this document are included five sections. Firstly, background, which explains big data definition and characteristics. In second place, a SWOT analysis for big data in healthcare, where are described the strengths, weaknesses, opportunities and threats. Lastly, the discussion and conclusion, which contains a reflection on the analysis previously presented and final considerations, respectively.

2 BACKGROUND

Despite being a recurring term nowadays, due to its complexity and heterogeneity, there is no clear definition of the term (Dave & Kamal, 2017). According to a questionnaire conducted by SAP, in 2012, the majority define Big Data focusing only on the huge growth in the amount of data generated and processed (Gandomi & Haider, 2015). A good example is McKinsey & Company that define big

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data as datasets whose size compromises the competence of traditional database software for the storage, management and analysis of data (McKinsey & Company, 2011).

Obviously, in sequence of the previous definition, the characteristic that is most easily associated with big data is volume, but there are others. Doug Laney, in 2001, created the 3Vs of big data that emerged as the most common and accepted way to characterize big data (Dave & Kamal, 2017), as described after and showed in figure 1.

- **Volume:** Corresponds to the amount of data that is collected or generated by organizations or an individual (Lee, 2017);
- **Variety:** Corresponds to the type of existing data which may be of the structured, semi-structured and unstructured type (Lee, 2017);
- **Velocity:** Corresponds to the high rate and speed at which data is created, captured, refreshed and shared from milliseconds to hours (Ambigavathi & Sridharan, 2020).

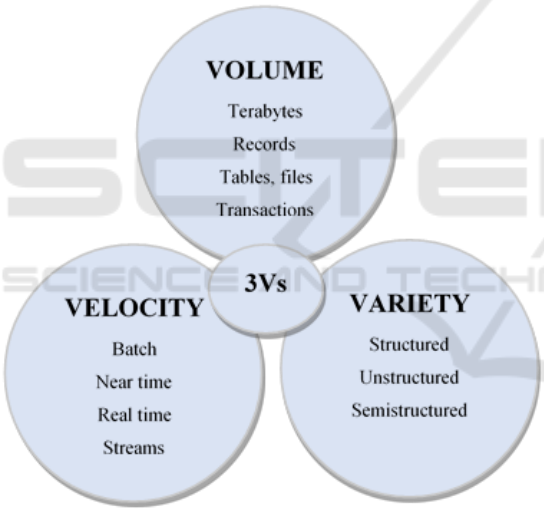

Figure 1: 3Vs of Big Data.

Subsequently, two new characteristics were identified by IBM and Oracle, which complements the 3V model previously described. These new discoveries have led to the creation of the Big Data 5V model, which contains, beyond the dimensions already known, Veracity and Value. Each of them will be described below:

- **Veracity:** Represents the lack of reliability and uncertainty inherent in some data sources, these may suggest due to imprecision, inconsistency and subjectivity in data (Gandomi & Haider, 2015). For example, consumers' feelings are not reliable since they include the subjectivity of their opinion (Lee, 2017). On the other hand, it's defined as the combination of data consistency and data trustworthiness which is necessary to provide effective results of a data analysis (Ambigavathi & Sridharan, 2020).
- **Value:** Corresponds to the value that big data can bring to organizations.

3 SWOT ANALYSIS FOR BIG DATA IN HEALTHCARE

In healthcare, data are disorganized and distributed from diverse sources, internal and external, often in multiple formats in multiple locations (Ambigavathi & Sridharan, 2020). So, when we talk about healthcare data, it can be physiological, behavioral, molecular, clinical, medical imaging, medication prescription history, nutrition and many more (Mehta & Pandit, 2018). Despite all this dispersion, it is based on these sources of information that health professionals make decisions and provide appropriate and efficient treatments.

Due to this phenomenon that is upon us, it's important to explore solutions that fit the clinical context, allowing to enjoy the many advantages and opportunities in this sector. Doing that successfully, can be determined by how well we understand the strengths, weaknesses, opportunities and threats of big data in healthcare (Ahmadi, Dileepan, & Wheatley, 2016).

Considering a bibliographic review based on a articles and researches of various platforms such as "Google Scholar" or purely "Google", we conducted a SWOT Analysis for big data in healthcare. In this research the following restrictions were considered: articles only written in Portuguese or English and with the year of publication less than ten years.

As definition, a SWOT analysis can be described as a technique used to determine and define the strengths, weaknesses, opportunities, and threats in order to assessing the performance, competition, risk and potential of a business (Grant, 2019).

3.1 Strengths

The fundamental strength of big data can be easily associated with the three Vs it represents: volume, velocity, variety. Regarding volume and velocity, over years, the health sector has generated and collecting large amount of data from record keeping, regulatory requirements and patient care which has been costly and time-consuming (Ahmadi et al., 2016). Essentially because most data were stored on

paper, but now the trend is toward digitization of this large amount of data. Nowadays, when it comes to data generated by these organizations in this industry, this includes prescribing data, administrative data, patient data in management systems, sensor data, social networking data, blogs, medical journal articles, and more (Raghupathi & Raghupathi, 2014).

According to (Mehta, Pandit, & Kulkarni, 2020), healthcare has seen a transition from clinical-centric care model to consumer-driver care model. In the consumer-driver care model, the patients won greater responsibility for their own health with a lot of digital applications to control health. This increase pace of generation of data brought an explosion of digital healthcare data, velocity and heterogeneity (Mehta et al., 2020). This real-world evidence has all the potential to make the system more efficient of care because open datasets mean that people from different areas can analyze data and test hypotheses, bringing fresh perspectives and open collaboration (Collins, 2016).

Analyzing these data volumes, through big data analytics, can add value to the organization, for example, discovering new correlations between things never thought before, patterns, and trends with data, thereby improving care, saving lives, and lowering costs (Raghupathi & Raghupathi, 2014). In a smaller view, providing access to relevant and high-quality data, healthcare providers and patients have better conditions to make decisions in the daily bases.

Big data will continue to grow in all areas fueled by the continuing growth of internet of things and this is one of its natural strengths (Ahmadi et al., 2016). Another strength of big data, that is a complement of all previously referred, is providing a big sample of data that permits validate the performance of statistical models developed. This strength is very important in healthcare sector because treatment models have changed in order to use data-driven findings to predict and solve a problem before is too late.

3.2 Weaknesses

To accomplish the benefits that big data can deliver it's necessary to define effective policies and procedures for handling and maintaining big data (Ahmadi et al., 2016). In order to deal with big data is required new infrastructures able to address volume, variety and velocity regarding data. It's also necessary scalability, capacity of operating and support immediate response for a large amount of medical data, including images, in order to reduce medical error (Sarkar, 2017).

As it is known, healthcare data is multidimensional and highly segmented. The possible lack of synchronization, generation of data in real-time or near real-time, amongst data sources can create gaps and misleading information (Mehta et al., 2020). The unification of data from multiple sources, including the conversation into common formats, is also another challenge of data acquisition. Added to this, storage data from multiple sources leads to data redundancy problems and it's difficult to aggregate data, considering separate useful information and discard redundant or irrelevant data (Mehta et al., 2020).

Another major weakness of big data is the risk of poor quality insights gathered from the data (Ahmadi et al., 2016). The accuracy and integrity of data is a concern because healthcare has a lot of different formats and sources of data. There is a need for information extraction process capable of selecting the essential information and present it in an adequate form for analysis, which is a technical challenge (Mehta et al., 2020). In order to be capable to produce meaningful use of data, cleaning and normalization by removal noise or irrelevant data is imperative (Mehta et al., 2020). In this sector, is extremely necessary to have reliable and reproducible results data, especially in medical and pharmaceutical research where gathering data is very expensive. With new analysis methods being developed quickly, the origin and quality of data can be significantly important to have good results (BDV, 2016). Regarding data access and sharing, there are barriers, technical and organizational, that limit the distribution of healthcare data among different institutions. The data collected is not shared between institutions, not even between departments (BDV, 2016). This leads to data that are not fully exploited and consequently, insights that can't be done.

The digitalization of healthcare service lead to a generation of very large volumes of data and heterogeneity, which is a consequence of multiple information systems and data sources. This scenario led to a lack of interoperability and coordination between medical service providers and consumers, causing erroneous diagnostics, greater operating costs or even, non-adherence top treatment plans by the patients (Satti et al., 2020). By definition, interoperability represents the policies and guidelines that can bridge the gap between systems and services. Data interoperability is a part that focuses on resolving integration, exchange and consumption of data (Satti et al., 2020). In healthcare, this is a weakness because some healthcare information management systems do not utilize any format

standard to build their schemas. And, in order to be able to use data effectively, the devices should be able to communicate in a standard and compatible format with other devices (Mehta et al., 2020).

Lastly, according to Nathan Eagle, cited by (BDV, 2016), there are not enough trained professionals comfortable to deal with petabytes of data, until this factor is remedied, this will remain a serious weakness. The skills required are not simple, they involve data mining, analysis, manipulation and other techniques expensive for most small firms to master (Hong et al., 2018).

3.3 Opportunities

Without any doubt big data has the potential to cause impact in technology, economic and society, boosting innovation and improving business models. According to (BDV, 2016), big data will open new opportunities and enable breakthroughs in very different perspectives:

1. Descriptive to answer what happened;
2. Diagnostic to answer the reason why happened:
3. Predictive to understand what will happen;
4. Prescriptive to detect how we can make it happen.

Regarding prevention and health promotion, big data can improve lifestyle support providing effective tools for behavioral change and provide a picture of what influences progress and reverse in any therapy. A great example is mobile health that has the capability to personalize interventions, using lifestyle data (sleep, nutrition and activity) from large reference populations (BDV, 2016). With these technologies it's possible to expand recording medical data not only to hospitals and doctors but also to home care models. Combining smart home technologies, wearables, periodic vital sign measurements, home care providers will be supported by a big healthcare infrastructure, while individuals are encouraged to live longer on their own (BDV, 2016).

Public health is another area that will benefit from the application of big data, using a nationwide patient and treatment database, public health can ensure the rapid, coordinated detection of infectious diseases and improve response (McKinsey & Company, 2011). According to the European Center for Disease Prevention and Control, cited by (BDV, 2016), 100 000 patients are estimated to acquire a healthcare associated infection in Europe each year. At least 37 000 deaths occur as a direct consequence of these infections. Combining information from informal (social networks, forums, chats, social sensors, internet of things devices) and formal sources (surveillance, diagnostic data) also provide earlier detection of disease outbreaks and information for understanding transmission in order to coordinate quarantine and vaccination responses (BDV, 2016).

Big data has given healthcare a huge opportunity to improve the quality of treatment. As it's showed, ultimately, the aim of big data in healthcare is to provide the patient's health data to make major decisions considering their needs, in order to be more efficient from the start. However, much more can be explored starting from research and development, which involves predicative modeling for new drugs and determine the most efficient allocation of resources, using of statistical tools to improve the design of clinical trials and analyze disease patterns and trends to model future demand and costs (McKinsey & Company, 2011). Certain developments or outcomes may be predicted and/or estimated based on vast amounts of historical data (Raghupathi & Raghupathi, 2014). Even in regular clinical operations the use of data is important to conduct a research to determinate which treatment will work best for specific patients, deploying clinical decision support systems to improve the quality of the operations and analyzing data to identify performance opportunities (BDV, 2016).

It's essential for a healthcare organization integrate multiple data, in order to allow more efficient decision-making, productivity and consequently, optimizing workflows. With big data technologies is not also possible to integrate all systems like electronic medical records, patient monitors and laboratory data but also implement automated systems for fraud detections and explore new business models (McKinsey & Company, 2011). The first type of new business model is one that aggregates and analyzes patient records to provide to third parties. Other potential business is online platforms and communities (McKinsey & Company, 2011).

Lastly, but also very important is the economic potential of big data in healthcare. According to a study conduct by Accenture in 2014, a third of European hospitals had reported operating losses (BDV, 2016). This is due the fact of being extremely difficult to provide good quality care at reasonable costs. However, big data has the potential to disrupt this industry and optimize quality, access and cost simultaneously (BDV, 2016).

Table 1: SWOT analysis of big data in healthcare.

Strengths	Weaknesses	Opportunities	Threats
• Volume; • Variety; • Velocity; • Value to organizations; • Better decision making; • More efficiency; • Continuous growth.	• Lack of adequate infrastructure; • Data acquisition; • Data aggregation and storage; • Data access and sharing; • Interoperability; • Risk of poor quality insights; • Lack of trained professionals.	• Improve lifestyle support; • Improve public health; • Reduce costs; • New business models; • Fraud detection; • Patient-adjusted treatments.	• Data privacy; • Data security; • Lack of incentive; • Ethical/moral questions; • Misuse of information;

3.4 Threats

Is crucial to store health data in a secure and privacy-respecting database. According to study conducted by (Alexandru, Radu, & Bizon, 2018) the main concern when discussing big data in healthcare is privacy and security of health-related data. Security breaches, hackings, phishing attacks and ransomware episodes happen, and healthcare data are more sensitive than other types of big data, that's why data security is a priority for healthcare organizations. After noticing an array of vulnerabilities was developed a list of technical safeguards by protected health information (PHI). Termed as HIPAA Security Rules, these rules help guide organizations with storing, transmission, authentication protocols, controls over access, integrity and auditing (Dash, Shakyawar, Sharma, & Kaushik, 2019). Anonymization and pseudonymization approaches are also a valid solution to guarantee privacy.

By users, there is a lot of skepticism regarding "where the data goes to", "by whom it is used" and "for what purpose" is present in most citizens and public opinion because the divulgation of medical information or lifestyle data can compromise individuals or their families (BDV, 2016).

An important issue that must be addressed as a threat is the lack of incentive for organizations to face technological challenges. The key question that any health organization faces is what is the return on investment for my hospital to implement big data? (Adibuzzaman, DeLaurentis, Hill, & Benneyworth, 2017). Even the current model of pay-per-service does not make sense, once big data will be able to carry out preventive analyzes in order to reduce or mitigate diseases. Thus, healthcare organizations would bill less, which is not an advantage for themselves.

The growth of information available to the user, if not well managed, can cause in some cases anxiety and stress. Since there will be a greater understanding about individual risk of diseases, in particularly for diseases with no treatment available, can create unnecessary concern in people. The use of all of this information can raise ethical/moral questions and lead to misuse of data by insurers because companies will soon be able to predict healthcare cost using big data applications. This threat might cause a backlash in health economics if people feel that their data are being misused or being over-monitored (Collins, 2016).

4 DISCUSSION

Big data and big data analytics, particularly in health, are some of the hottest buzzwords at the moment. However, nobody really knows how to do it but everyone thinks everyone else is doing it (Health, 2016).

Based on the previous literature review and SWOT analysis, big data in healthcare is a field with more strengths and opportunities when comparing with weaknesses and threats. Analyzing Table 1, it's possible to visualize that were identified seven strengths, seven weaknesses, six opportunities and five threats.

Regarding strengths and weaknesses, big data in healthcare can provide better decisions making and, consequently, efficiency of care. But some strengths can turn into weaknesses. For example, the three Vs of big data (volume, velocity and variety) are a major strength because the amount of data generated, at high speed, in various data types can generate knowledge and value to organizations but also cause infrastructure issues, risk of poor quality data and data

aggregation challenges. However, there are more and more tools and techniques for storing, processing and analyzing big data, as is the case of Hadoop – a open source framework. In the case of the lack of professionals specialized in big data to implement these systems tailored to organizations, there are companies that provide big data solutions depending on monthly payments. Addressing interoperability problems, healthcare providers will need to develop a big data exchange ecosystem that provides trustworthy, timely and meaningful information by connecting all members of the care continuum. Time, commitment and communication would be required (Dash et al., 2019). Another weakness mentioned above is the lack of trained professionals but it's important to reminder that is a temporary situation once the world is preparing for big data, educating more and more big data experts and data scientists. Comparing opportunities and threats, opportunities are vast, in multiple areas, from financial to more quality healthcare. On the other hand, threats are based in two areas, privacy of personal data and lack of incentive to implement big data. To solve security and privacy issues, many businesses are trying to invest in processes and protocols in order to guarantee privacy and, consequently prevent massive data breaches. Common measures like up-to-date antivirus software, firewalls, encrypting sensitive data and multi-factor authentication can save a lot of trouble (Dash et al., 2019).

In general, despite the weaknesses and threats discussed here, cannot be denied the potential that big data has to offer in healthcare. The application of real-time data may have preventive effects, permitting faster identification of problems and, consequently a earlier application of the treatment. This can be extremely important to reduce the mortality rate and prepare medical staff to possible peak of workloads in situations like the flu and pandemic infections. But, how exactly can big data reduce waste and inefficiency? In several ways, as mentioned in the previous chapter, through big data it is possible to diagnose and treat patients more effectively in terms of clinical procedures and cost. It's also possible to make predictive modeling that allows the production of new devices and drugs more quickly with the intention of enhancing the reduction of possible failures and a better combination between treatment and patient's disease. In addition, big data facilitates pattern analysis and disease monitoring to increase the speed of response, faster vaccine development and turn large amount of data into relevant information to identify needs, provide services, predict and prevent crises or event the rapid analysis of medication reimbursement requests in order to reduce fraud. The combination of financial, operational and clinical data constitutes a very important asset provided by the application of this revolutionary technological concept.

Considering everything mentioned in this article, the main requirements needed for realizing the potential of big data are, in first place, evaluate commercially and affordable tools or services that enable scaling up the use of big data analytics in healthcare. In second, it's important to choose a big data platform that support the key functions necessary to overcome weaknesses, threats and that responds to the needs of the business. The criteria for evaluating the best big data platform/technology should focus on ability to manipulate data at different levels of granularity, data privacy, security, scalability, quality assurance and easy to use. With this, value and information will be added for decision making and the resistance to change will be less. In third, make sure that exist a solid exchange ecosystem between all members of care community, in order to ensure data access and sharing. Lastly, an incentive to exploit data. According to (Health, 2016), healthcare providers have been compensated on a fee-for-service model. However, this does not incentivize moving to a pre-emptive care model once it can be expressed in a lesser visit to medical services and consequently, less financial returns. A model like fee-for-value would motivate more healthcare providers to invest in big data.

Globally, healthcare is seeing a surge of interest in the use of big data. According to (Schroer, 2019), big data is already taking on some of the biggest challenges in healthcare, as it's possible to analyze in the following examples of companies/organizations that are already extracting knowledge from big data:

1. **Flatiron Health (New York):** Utilizes billions of data points from cancer patients in order to gain new insights for patient care. Their solution enables multiple players (oncologists, hospitals, academics,) to learn from each patient. Flatiron partners with over 280 community cancer practices, 7 major academic research centers and over 15 of the top therapeutic oncology companies (McCall, 2020).
2. **Pieces Technologies (Dallas, Texas):** Is a cloud-based software company that collects data from patients in order to improve quality and cost of care. Their platform makes decisions and recommendations based on the most varied data such lab results and vitals;

3. **Amitech (St. Louis, Missouri):** Utilizes data for population health management solutions, combining health data to identify risks and engage patients in their own healthcare;
4. **Apixio (San Mateo, California):** Utilizes information from millions of files, claims, PDFs and other health records to provide more accurate risk adjustment for healthcare providers.
5. **Innoplexus (Hoboken, New Jersey):** creator of iPlexus that organizes millions of publications, articles, clinical trials and more documentation into a concept-based research platform. The purpose of this tool is to help pharmaceutical companies finding relevant information for new drug discovery.
6. **Ellipsis Health (San Francisco, California):** Offers a different approach, tackling depression and anxiety. Using a few minutes of speech per participant, analyzing audio, is developing a vital sign tool for mental health and wellness that detects depression and anxiety (McCall, 2020).

And many more, from analyzing patients with cancer to organizing millions of documentations, companies with high-tech approaches are growing and harnessing big data in health. However, there is still a long way to go. According to (Turea, 2019), a Dimensional Insight study found that 56% of hospitals and medical practice, in United States, do not have appropriate big data governance or long-term analytics plans and 71% of the people surveyed said they have found inconsistencies in data.

5 CONCLUSIONS

With the realization of this article it was possible to highlights the urgent need to understand the economic and strategic impact that big data brings to healthcare. This paper introduces a SWOT analysis in healthcare, where the main strengths, weaknesses, opportunities and threats are addressed. In addition, we summarize the main requirements needed for realizing the potential of big data and the criteria for evaluating the best big data platform/technology. In general, big data in healthcare faces a lot of weaknesses and threats, since interoperability to data privacy. However, the right and affordable investment adjusted with a favorable incentive to healthcare organizations and a data sharing ecosystem can bring innumerous strengths and opportunities. Among the many advantages, it is important to highlight the production of new devices, drugs, discovery of patterns, trends and associations with data able to improve care efficiency, provide better decision making, save lives, decrease costs and provide patient-adjusted treatments. As a future work is important to understand the difficulties of organizations in this transition in order to investigate ways to overcome these problems. We believe that big data will add-on and bolster healthcare, instead of misuse of information and anxiety/stress due the information available to the user. Together, big data will facilitate healthcare by reducing waste and inefficiency.

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