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# How Prescriptive Analytics Influences Decision Making in Precision Medicine

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## Abstract

Failure of the old model of medical decision making, “one-size-fits-all”, has encouraged the healthcare/medicine landscape to take advantage of big data and analytics for tailoring the treatments[1], based on individual patient’s differences in gen, environment, and lifestyle [2]. Whereas literature has demonstrated a strong contribution to the adoption of healthcare analytics over patient’s data, for better decision making [3], understanding the level and the degree that each type of analytics influences decision making, is crucial for addressing the type of problems [4]. While descriptive, diagnostic, and predictive analytics generate knowledge for decision support systems, prescriptive analytics recommends a proactive decision[5]. This study aims to highlight the influential and effective role of prescriptive analytics for fulfilling precision medicine which is defined as an emerging approach in medical decision making [6].

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## 1. Introduction

From the general point of view, analytics is the combination of art and science for discovering meaningful and novel insight from volume and various data via applying techniques such as machine learning, mathematical and statistical algorithms, for supporting timely decision-making tasks [5]. As Fig. 1, demonstrates, in a simple taxonomy of analytics, whereas, descriptive and diagnostic analytics focus on what happened and why it happened, the predictive analytics, uses mining techniques (e.g., data mining, text mining, and web mining) for forecasting the

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future behavior and events [7]. Furthermore, prescriptive analytics, which is less mature and more advance, uses the outcomes generated from the other analytics for performing the best possible action [5,8].

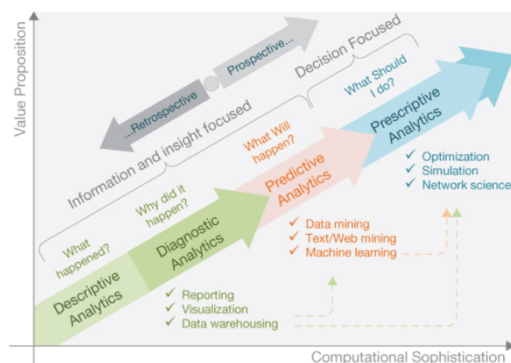


Fig. 1. Analytics [5].

The applications of big data analytics in healthcare, which uses the cutting edge technologies to perform over the patient's data [3], has offered a remarkable opportunity for launching the new approach in medical decision making. Where individual patient variables including genes, environment, and lifestyle are taken into the account for tailoring the most suitable treatment [9].

The failure of the traditional framework of medical decision making which completely has relied on limited information about the patient and the experience of clinicians in the treatments [3], has resulted in the high cost of overtreatment, poor quality of healthcare services, and weak outcome [10]. Moreover, increasing the aging population, growing the number of chronic diseases, and consequently, the demand for special treatments, have challenged nations economically for switching the old protocol of medical decision making, "one-size-fits-all" into "patient-like-me". Such a new approach that considers the patient's variables and differences between the patient and patient condition [11].

The transition from the old protocol of medical decision making into the new model, "precision medicine" for releasing the right medicine with the right dose for the right person, is applicable via applying healthcare analytics over the patient's data [12].

This paper intends to highlight the influential role of prescriptive analytics for such a new framework in medical decision making. Therefore, the general perspective of healthcare analytics and decision making is discussed. Also, focusing on the role of prescriptive analytics with the new approach of medical decision making, two critical concepts are outlined: prescriptive analytics and precision medicine. Finally, in the end, the effective characteristics of prescriptive analytics for performing the best possible performance are explained.

## 2. Healthcare analytics and decision making

Literature has widely addressed the limited human cognitive for solving complex problems and the fact that, firms that apply analytics on big data, have been able to obtain more accurate and better outcomes in decision making [13].

The Healthcare industry is one of those fields that is becoming extremely data-driven, based on the large volume of data which is increasingly growing from various sources [14]; this data, is multi-dimensional (e.g., medical images, biomedical signals, audio transcripts, handwritten prescriptions, structured data) [3], complex, dynamic and unstructured. So, for the healthcare industry, to be able to cut down the cost of overtreatment, improve the quality of services, reduce human errors, and save more lives, analytics are vital. Where the advance analytics performs for releasing actionable outcomes and for facilitating medical decision making [15]. Furthermore, each type of healthcare analytics influence decision making in a particular and distinctive way [13,16]. For instance, early disease detection, prediction of a patient's status, fraud detection [17], and effective treatment plan which carries a better quality of services and cost-effective treatment [3].

Fig. 2, shows the five types of healthcare analytics which perform over the healthcare data. As it shows,

descriptive and diagnostics healthcare analytics, are used for discovering meaningful patterns and presenting the relationship between variables in the form of dashboards, visualizations, and graphical reports. Hence the results help clinicians to observe and analysis for evidence-based clinical practice. Such applications that perform with the simple level of analytics illustrates analysis and existing information about the patient's behaviour. For instance, a laboratory result or identifying a method for detecting cardiovascular disease in real-time by using smartphone deceive [18]. In such scenarios, the outcomes do not provide information for realizing which results are the most effective and actionable. In other words, the result of performing a simple level of analytics (descriptive and diagnostic) over patient's data is unprocessed and needs to be interpreted for medical decision making. Additionally, the massive volume of data that are unstructured, complex, and fragmented [19], makes this process even more difficult for clinicians to prioritize and deliver the most suitable treatment [10].

Furthermore, predictive analytics which deals mostly with information rather than data; use indicators to predict future opportunity or problem. Predictive healthcare analytics, which has been integrated with the daily healthcare industry, has become a transforming tool for offering predictive treatment [19]. For example, distinguishing the individual at risk is related to the particular disease [20,21] or predicting heart disease for an individual based on the patient's lifestyle [18].

The most sophisticated healthcare analytics performs when decisions should be made by evaluating different alternatives [22]. Prescriptive analytics provides answers to questions such as "what we should we do" according to the insight created by the other three analytics (descriptive, diagnostics, and predictive) [5]. Whereas the first three healthcare analytics provide information for decision support systems (observed, analysed, and predicted) [23], Prescriptive analytics presents the best performance of medical decisions [7].

Finally, discovery analytics provides answers for questions such as: what do we don't know yet; helping healthcare providers and researchers to identify unknown illnesses and medical conditions also for investigating new alternatives for treatment and medicine [24].

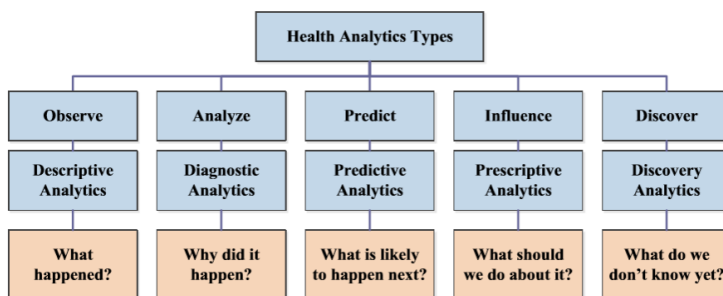


Fig. 2. Healthcare Analytic[16].

### 3. How prescriptive is advancing precision medicine

Precision medicine which was announced by the former president of the United States, Barack Obama, in 2015 has been identified as a promising advancement to impact automated medical decision making [25]. It intends to pioneer a new research framework accelerating the discovery of the right treatment, for the right patient, at the right time, [26]. It is important to clarify that, precision medicine and personalized medicine are two different concepts. Personalized medicine is designing and customizing a drug and it differs from tailoring the treatments for an individual patient [20]. Consequently, US National Library defines precision medicine as: "an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person" [6].

This new approach in medical decision making has been motivated by major aspects such as the failed business model of "one size fits all", where, the released treatment is effective for some patients but not useful or even harmful for other patients [1]. Furthermore, this type of approach which has resulted in poor outcomes and high cost of over treatment challenge the nations economically. Moreover, consumerism and less balance between patient expectations and quality of service offered by the care provider is another key reason for switching into precision medicine [27].

In addition to those negative consequences of the traditional framework of medical decision making, on the one hand, availability of the massive amount of patient's data from diverse resources and on the other hand, limited human cognitive for considering all data, timely in decision making, have offered the remarkable opportunity for analytics to advance precision medicine [28]. In other words, the new perspective in medical decision making takes advantage of big data and healthcare analytics for tailoring the patient's treatment based on the individual's longitudinal records (e.g., genetic data, clinical sources, medical records, tissue banks) [20].

Because the individual patient's data, carries features of big data, such as volume (the size of healthcare data is huge), velocity (refers to the speed at which data is being created and flow), variety (data is heterogeneous and diverse in formats, including text, image, multimedia content, audio, video and sensor data), veracity (if data which comes from uncontrollable is trustable in terms of quality), value (data is valuable) and variability (data is constantly changing) [5,13,27,29], considering the healthcare big data for timely decision making about the most fitted treatment, is beyond the human cognitive and this is a significant opportunity for sophisticated analytics such as prescriptive, to perform with the high componential ability for pioneering the precision medicine [30].

Consequently, when prescriptive analytics applies on three groups of individual patient's data, including genomic data, clinical data (e.g., structured and unstructured, medical image), and behaviour data (social network data, mobility sensors data) [27], the most effective medicine is obtainable as the best outcome [30]. Where prescriptive analytics uses the knowledge discovered by descriptive, diagnostics, and predictive analytic to evaluate alternatives and choose the optimum decision [5,31].

### 3. 1. Prescriptive analytics and the best possible action

Although the first three analytics (descriptive, diagnostic, and predictive) focuses on knowledge discovery for decision support systems, the extensive role of prescriptive analytics, yields on automated decisions [8]. This type of analytics uses what-if scenarios and perform to express and to determine the cause-effect relationship for obtaining the best possible performance [13].

As Fig. 3, shows, prescriptive analytics uses the outcome of predictive analytics for performing a proactive decision. Therefore, the timely detection of business status and predicted events are important for the possibility of business loss. Furthermore, the gap between the proactive decision is a time interval for preparing the action. Accordingly, at the time of accruing the event, descriptive analytics is applied to discover the insight; answering the question of what happened and why it happened [15].

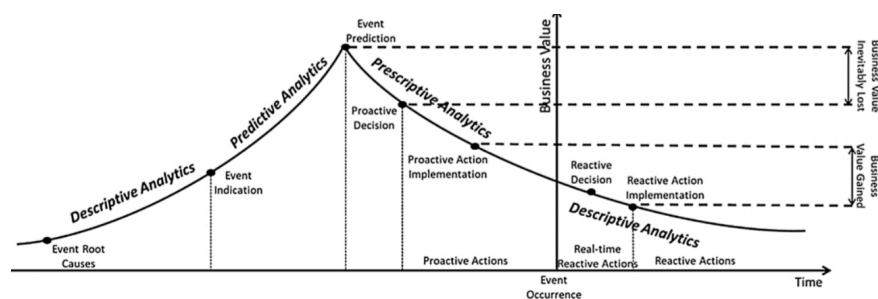


Fig. 3. Prescriptive Analytics [15].

Addressing a decision-making model needs searching for a suitable course of action via advanced analytics and algorithms. Prescriptive analytics is the most advanced type of analytics for assessing each of the generated alternatives based on balanced goal attainment. There are techniques such as optimization, simulation, heuristics, and multi-criteria decision making, and also enablers (e.g., deep learning, cognitive computing, and big data) which affect the quality of the result [5].

The performance and success of prescriptive analytics depend on considering the hybrid data (structured and unstructured), also the alternatives which are generated from the prediction phase influence the performance. Moreover, applying adaptive algorithms for tailoring the result based on key factors affect the reliability of the outcome [22]. Additionally, sensitivity analysis examines the validity of each algorithm and what-if scenarios help

change the parameters for meeting the objectives [7].

#### 4. Conclusion

This paper highlighted the efficient role of prescriptive analytics over the patient's data for medical decision making in precision medicine. While other analytics (e.g., descriptive, diagnostic and predictive) create knowledge for decision support systems, prescriptive analytics, as an advance and less mature analytics recommends the best possible result. In fact, the influential performance of prescriptive analytics is considerably important for replacing the old protocol of medical decision making, “one-size-fits-all” to “patient-like-me” where the most fitted treatment is achievable by considering the individual patient's data (e.g., gen, life style and environmental). As the future work, it is intended to propose an intelligent decision support framework for a specific disease based on the new approach of medical decision making, whereas, prescriptive analytics uses patient's for recommending a goal attainment and proactive decision to obtain the most suitable treatment.

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