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To what extent healthcare analytics influences decision making in precision medicine

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Abstract

Although Healthcare Analytics (HA) plays a critical role to uncover the link between data and discover novel and actionable information, the level that each analytics influences clinical decision-making is different. This paper aims to highlight the role of each HA in respect to Precision Medicine (PM). Where, PM is defined as a new approach in medical decision-making that takes into account individual differences in genetic, environmental, and lifestyle indicators. Besides, Simon's model in decision-making assesses the performance of clinical decision-making followed by HA. In addition, SOAP framework is discussed as an example under the influence of HA for adopting PM.

Keywords: Clinical decision making; Precision medicine; Big data analytics; Healthcare analytics; knowledge discivery; Optimization;SOAP;

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1. Introduction

Availability and accessibility of the high volume of healthcare data, not only challenges the limited human's cognition for timely decision making but also offers a remarkable opportunity for Healthcare Analytics (HA) to

discover novel insight from data. Where projecting big data analytics over healthcare data accelerates the shift from a traditional protocol of medical decision making to Precision Medicine (PM) [1].

Healthcare data is heterogeneous (vertically partitioned), multi-dimensional, fragmented , semi/unstructured and comes from various resources [2] . Moreover, emerging sensors technologies via IoT (Internet of Things) platform in healthcare [3], wide projection of Electronic Medical Records (EMR) and human generated data (e.g., ad administrative, operation, treatment plans, demographic) have resulted in creating large volume of data [4] . Thus this data needs big data analytics to be useful and supportive for decision making. The outcome of such process is able to fulfill the new approach in medical decision making (PM). In other words, PM aims to use individual health data including genetic profile, environmental and life style variables in a customized way to improve the quality of healthcare service, increase the performance, cut the cost of over treatment, minimize medical errors and side effect and save more lives. To achieve this objective, the role of healthcare analytics is significantly critical [5].

Although HA empowers the adoption of PM, the degree that each analytics influences decision-making is different. In general, based on the level of difficulty, value and intelligence, three major classes of analytics are descriptive/diagnostic, predictive and prescriptive [6]. Where descriptive/diagnostics and predictive are informative, prescriptive is a decision focused with the highest value-added on obtaining the best possible outcome. Therefore, applying HA over individual patient data demonstrates different performance particularly for utilizing PM.
This paper intends to highlight the level of effectiveness of each big data analytics over healthcare data in respect to the PM. In order to analyse the contribution of each analytics in accurate and transparent decision making, Simon's model in decision making is presented. Accordingly, the performance of each HA is explained and SOAP framework as an example is analysed. Finally, the discussion part justifies the role of HA-based on the theoretical foundation; finding are presented according to this theory assessment.

2. Simon's model in decision making

"Intelligence, design, choice" introduced by Herbert Simon, has been widely used by the scholar as the most complete framework for problem-solving or decision making task. Simon later added the fourth phase which is about "Implementation". The first step: "design", includes activities associated to search and collect information via scanning the environment. Moreover, problem identification and setting the objectives are important to define the problem. This phase may include the results or feedback from the "implementation" phase [7]. The second phase is about alternative generation and developing possible courses of action. Moreover, identifying various scenarios and outlining the consequences of each alternative [8]. The identified alternatives are evaluated and validated in the "choice" phase. Therefore, the third phase is associated with selecting the best possible option. In other words, to what extent the best performance solves the problem and meet the objective. Finally, the "Implementation" phase makes the selected option work. Each step has a feedback loop and the outcomes of each step are communicated until the final choice will be selected [9]makes the selected option work. Each step has a feedback loop and the outcomes of each step are communicated until the final choice will be selected [9].

3. How does healthcare analytics pioneer precision medicine

3.1 Precision medicine

According to figure 1 and based on the definition of PM announced by the U.S. National Library of Medicine, Precision Medicine is introduced as a new approach in medical decision making that takes considers individual differences in genetic profile, environmental, and lifestyle factors for disease prevention and treatment [11], [12] This new approach in medical decision-making was initiated by former President Barack Obama, on January 20, 2015, for improving public health via cutting the cost of [i]overtreatment, minimizing medical side effects, and increasing the quality of healthcare services [13].

Fig.1. Precision Medicine [5]

3.2 Healthcare analytics and clinical decision making

Since healthcare data is characterized by features of big data (V6) including variety (different format of data), velocity (the speed of generating data & flowing), value (data is valuable) and variability , volume (data size) and veracity (quality & how data is trustable)[14],[15], therefore such data demands big data analytics to demonstrate the exnensive use of data to facilitate reliable decision making [6], [3].

The general classification of data analytics is descriptive/diagnostic, predictive, prescriptive. Whereas the first two analytics have been emerged widely in healthcare domain, less clinical practice has demonstrated the useful adoption of prescriptive analytics. Considering the degree of maturity, each analytics presents different levels of intelligent, complication and value for problem solving.

According to fig 2, based on the functionality of each HA, descriptive and diagnostic (as a subset of descriptive analytics) help the physician to observe and analyse the situation; answering the question of what happened and why did it happen. For example, the result of a laboratory exam demonstrates useful information for identifying the status of the patient in regards to a particular illness. This type of analytics is important to detect a particular disease at an early stage for effective treatment. Moreover, efficient and quick detection of health care fraud is another benefit of using diagnostic analytics. [16]. The next level of HA forecasts the future event. For instance, predicting the individual who is at the risk of infection or mortality [17]. Other examples are, identifying the patient who needs to change the lifestyle, and predicting disease progression and epidemics are some of the functionalities of predictive analytics to cut unnecessary hospitalization, control disease development, and reduce preventable death. Therefore, Predictive analytics is critical for preventive care and developing vaccines[18]. Furthermore, prescriptive analytics which is the most sophisticated and the least mature analytics is associated to find the best possible performance. For example, recommending the best possible treatment pathway [19], [20]. Finally, discovery analytics answers to questions such as what do we do not know? For instance, what are the medications or diseases that are not identified yet? [15].

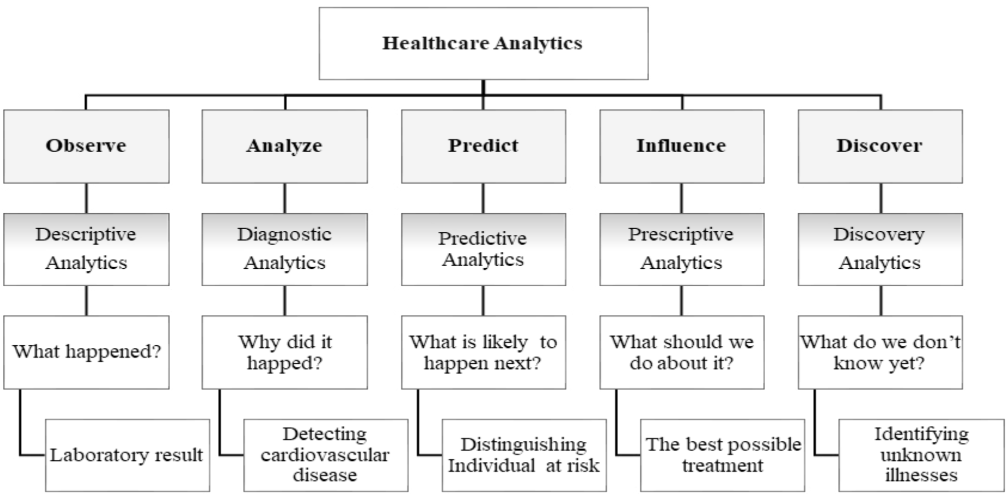

Fig. 2. Healthcare Analytics & clinical decision making. Adopted from [20]

3.3. Performance of SOAP framework under the influence of HA adopted in PM

Progress in adopting AI techniques (e.g. Machine learning, data mining), analytics, and IomT not only advance accurate prediction and care-based health service but also the availability of the high quality of wide range of individual patient data accelerate precise treatment and cure-based service [21].
Figure 3, summarized major performance of each analytics and also the degree that they influence decision making in PM in respect to the SOAP framework. As it is presented, the first two analytics demonstrate current situation and summarize the past events such as medications and treatments. The extracted information and discovered knowledge help the physician to understand the patient's past behavioural patterns. The result of this performance which are communicated with reports, tables, graphs and dashboards [22] presents the "subjective" and "objective" associated with SOAP. SOAP is a clinical framework for structuring clinical notes and facilitating decision making. Where "subjective" explains the symptoms and provided by patient, "Objective" addresses sign and presented by physician, "assessment" explains reasoning and "plan" is about treatment. Moreover, descriptive and diagnostics analytics empower high accurate automatic classification of "subject" and "object" where "assessment" needs interpretation of the reports and completely depends on physician's judgement, skills and experience for releasing the decision. An automatic classifications of "subject "and "object" not only resulted in accurate identification of disease's, but also this automated structure improves performance in extracting existing medications and treatment plans recorded in individual patient's clinical data.[23]. Furthermore, predictive analytics that is enabled by technologies such as text mining, data mining, and web mining, is critical for disease prevention and care approach. Moreover, applying predictive analytics over patient's data empower generating treatment features which is associated in "Assessment" phase in SPOAP structure. The predicted features of treatment pathway are important for the prescriptive analytics to evaluate and present the precise medical/clinical solution. For instance, predicting the spread condition of infectious disease with high spread's risk is important for developing possible plan for disease management strategies and preparing possible cure scenarios [22].

Although descriptive, diagnostics and predictive analytics discover novel insight from healthcare data, identify useful patterns and also possible care scenario [12], they are informative and needs interpretations. In other words, the least complicated analytics performs to propose accurate and transparent input for Clinical Decision Support Systems (DSSs) [10], [24].

Prescriptive analytics performs through the cause-effect solution and what-if scenarios to optimize clinical pathways. Visualizing the consequences of this performance resulted in obtaining the best possible treatment pathways [25].In other words, the physician can determine the possible effects of each alternative or decision by projecting simulation and optimization techniques. Therefore, this gives possibility for practitioners to be prepare to manage any event in case of failure or success [22]. Based on this definition, prescriptive analytics can be justified as "Plan" part of SOAP and since this level of performance in respect to the PM approach might be deciding about treatment solution whether for prevention or dealing with illness, the role is associated in both: cure and care approach. Finally, discovery analytics perform to demonstrates unknown events. Where developing new drugs, identifying new disease, new symptoms and even new treatment scenarios such as vaccines are the outcome of this functionality. Based on that, this type of analytics is care and cure based. In addition, discovery analytics might be influential to automate "subjective" and "objective" categorization in SOAP structure.

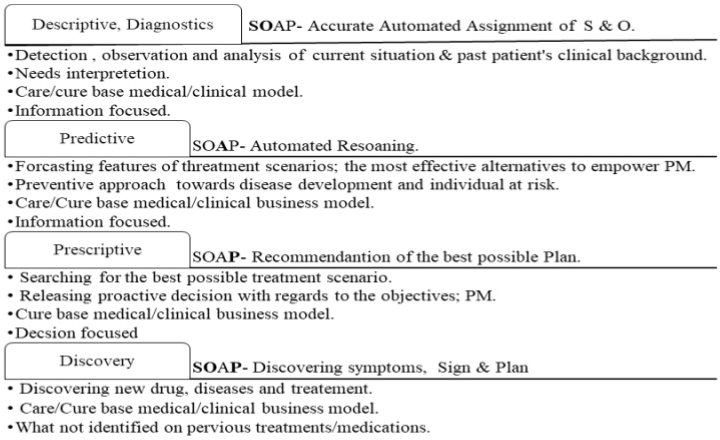

Fig.3. Influence of healthcare analytics in clinical decision making with respect to PM & SOAP

3. Discussion and result

As it was explained above and according to table 1, descriptive and diagnostics analytics that focus on knowledge discovery and identifying novel from insight data belong to the "Intelligence" phase. where this phase is associated with searching the environment and collecting data/information. Moreover, predictive analytics identifies the relationship between features and uses historical data to forecast future performance in the form of information that is also associated in "Intelligence" phase. In addition, predictive analytics releases various possible alternatives such as treatment scenarios and medical features, so we can conclude that this performance plays similar role as "design" phase. Where the outcome feeds the next phase of Simon's model in decision making which is "choice". In other words, the alternative generated by predictive analytics would enable sensitivity analysis, what-if scenarios, and cause-affect models for evaluation. Assessing those alternatives and the consequences of each of them is performs by prescriptive analysis. Hence, the prescriptive analytics performs like "choice" phase, where the sub-optimal decision is realised according to the comparison and assessments of each potential alternatives. In other words, the most complicated and value added analytics to empower PM is prescriptive analytics that recommend the best possible performance with respect to the objectives. Furthermore, where SOAP is discussed as an example that accelerate adopting PM under the influence healthcare analytics, it can be concluded that since "plan" is the critical phase which can perform with high accuracy and transparency under the influence of prescriptive analytics, thus this part of SOAP framework demonstrates the "choice" phase of Simon's model in decision making. In addition, as it is presented in table 1, although automated classification of "subject" and "object" support decision making task, but they demonstrate precise information for decision maker and still needs interpretation and DSSs. Therefore, they are associated in "intelligence" phase. Besides, "assessment" belongs to both "intelligence" and "design", because predictive analytics is able to release automated assessment performance.

Table 1. Theory assessment

Simon's Model in Decision Making	Healthcare Analytics					SOAP			
	Descriptiv	Diagnostic	Predictive	Prescriptiv	Discovery	Subjective	Objective	Assessme	Plan
Intelligence	X	X	X		X	X	X	X	
Design			X					X	
Choice				X					X

4. Conclusion

This paper aimed to discuss the role of each healthcare analytics for empowering the projection of precision medicine. PM is defined as a new approach in medical decision making where individual patient's data (genetic profile, environmental and life style variables) is considered for realizing the best possible treatment scenario with respect to the objective. Whereas, descriptive, diagnostic and predictive analytics are information focused and require interpretation to support decision making, prescriptive analytics is identified as a decision focused that performs with the highest affect for obtaining the best possible solution. Moreover, SOAP framework is explained as an example where analytics influence accurate and transparent automated structure of SOAP. This automated structure directly facilitates adoption of PM in healthcare. Where "plan" has a direct association with prescriptive analytics. Finally, the Simon's model of decision making assessed the role of each analytics for accelerating PM and it is highlighted the role of prescriptive analytics as a decision focused analytics associated in "choice" phase.

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