Application of Data Analytics to Improve Patient Care: A Systematic Review

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Abstract

Data analytics continuous to drive positive change by enhancing internal operations and external relationships between organizations and communities. Data analytics is the use of scientific and mathematical techniques to derive meaning from factual information thus gain better insights. Patient care encompasses the healthcare services that are rendered for the benefit of patients. It is important to note that patient care systems around the world have focused on improving the health and experience of the individual by leveraging various inputs such as modern technology. This study sought to conduct a systematic review the application of data analytics towards improving patient care.

The specific objectives were to investigate the concept of data analytics and its applications, understand the application of data analytics in healthcare, determine the implications of data analytics in improving patient care, and establish the challenges and opportunities of data analytics towards enhancing patient care. The study employed a number of theoretical frameworks as foundation for understanding the relationship between data analytics and patient care. These theories were the Magical Thinking Theory, the Lightweight Theory, and the Classical Mathematics Theory. The study employed systematic reviews that collate the outcomes of research studies thus obtain a collective estimate of the intervention effect.

The eligibility criteria for the research studies include the study population, time, type of intervention, study variables, quality of the research methodology and linguistic and cultural range. The findings from the systematic review were that data analytics had a significant impact on the healthcare sector especially when it comes improving patient care. The study rejected the null hypothesis and thus accepted the alternative hypothesis that stated the importance of data analytics in improving patient care.

Keywords: Data Analytics, Patient Health, Prisma, Data Cleaning, Interpretation of Data, Digital Health.

1.0.   Introduction

Data analytics is regarded as a technological revolution that continuous to drive positive change across organizations by enhancing both internal operations and external relationships with individuals and communities. Data can be defined as information in terms of statistics or measurements that can be used as a basis and foundations for calculations, reasoning and discussion (Shekarian, Ramirez, & Khuntia, 2020). There are two types of data that include qualitative data that is usually expressed in a narrative or verbal form and quantitative data that is presented in numerical form. Data analytics refers to the utilization of various scientific and mathematical methods to derive meaning from factual information thus gain better insights about objects, people, processes or organizational units (IFAC, 2018). It is important to incorporate data analytics as it reduces costs, enables faster decision making and minimizes risks especially within healthcare. Below is an image illustrating the process of data analytics:
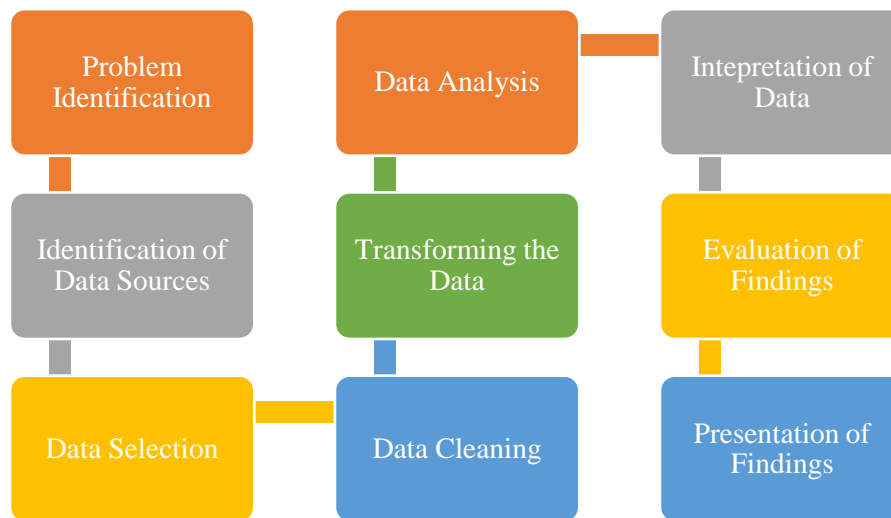
Fig 1: Process Map for Data Analytics

On the other hand, patient care refers to the services that are rendered by healthcare professionals including doctors, nurses, and management personnel for the benefit of patients (Yorke, 2017). The concept has been widely discussed in the field of healthcare and research with the aim of highlighting the most appropriate definition. In some instances, the provision of patient-centered care has been fronted as a more elaborate explanation of services rendered to patients with the terminology describing patient care as the provision of health services that improves the health and experiences of the individual. Patient care systems around the world have focused on improving the health and experience of the individual by leveraging various inputs such as modern technology (Lewis, 2019). Therefore, it is important to understand the different technologies that can be applied in the field of healthcare thus improve patient care and thus achieve the most sought-after patient centered healthcare system.

2.0.   Background

According to Shekarian, Ramirez and Khuntia (2020), data analytics as a process of transforming, managing, and modeling data towards deriving meaningful information plays a critical role in improving hospital performance. The study revealed the sparse nature of evidence related to the interplay between data analytics and operations in healthcare. However, the research sought to close the gap by evaluating the impact of data analytics in health and clinical operations. The findings were that the relationship between data analytics and hospital performance tend to be highly complex hence the lack of similar evidence. A study by Wang and Alexander (2019) revealed that big data analytics has the potential to improve patient outcomes while advancing and personalizing care. The research also highlighted the capability of data analytics enhance the performance of healthcare systems by improving relationships between healthcare providers and patients as well as reducing medical spending.

Furthermore, Dash et al., (2019) investigated the conceptualization of big data in healthcare with regards to overall management, analysis, and the future possibilities. The study sought to understand the impact of big data and its analytics in the field health and clinical medicine by assessing the role played by the concept in both healthcare operations and research. The authors revealed that big data analytics leveraged the perceived gap that exists within structured and unstructured sources of data thus enabling a shift to the problematic integrated data system that affects the provision of quality healthcare. Gemson and Durga (2015) conducted a study to understand the background and techniques of big data analytics that have been applied in healthcare. The research reviewed the application of big data analytics in health systems as well as the platforms, algorithms, pros and cons of the technological concept while providing a discussion of the future areas of interest.

2.1. Research Objectives

The study comprised of both general and specific objectives. The general objective was to review the application of data analytics towards improving patient care.
The specific objectives were:

i.   To investigate the concept of data analytics and its applications.
ii.   To understand the application of data analytics in healthcare.
iii.   To determine the implications of data analytics in improving patient care.
iv.   To establish the challenges and opportunities of data analytics towards enhancing patient care.

2.2. Hypothesis

2.3. The study stated both a null and alternative hypothesis that guided the implantation of the systematic review. The hypothesis for the study were:

H_0 – There is no significant impact of data analytics towards improving patient care.
H_1 – There is a significant impact of data analytics towards improving patient care.

2.4. Literature Review

This section discussed the theoretical frameworks that provide the basis for understanding the link between data analytics and patient care. The study sought to review the application of data analytics towards improving patient care. The theories identified as a foundation for understanding the relationship between data analytics and patient care included the Magical Thinking Theory, the Lightweight Theory, and the Classical Mathematics Theory. The Magical Thinking Theory postulates that we are inclined towards seeking and interpreting connections between the events that take place around us along with the disinclination to review our beliefs following deeper observation (Diaconis, 2016). The theoretical framework illustrates that in some instances, a single manifestation may be believed to be a sign and that a given ritual offer the method or technique to understanding. Therefore, the underlying belief tends to persist despite the existence of factual circumstance.

Secondly, the Lightweight Theory of data analytics emphasizes on making predictions based on the consolidation and acceptance of theoretical frameworks (Elragal & Klischewski , 2017). The theory is related to the domain of making predictions where big data analytics delivers predictions that rely on the execution of sequential data processing techniques. However, there are sentiments that propose the shift from a theory-driven prediction to a process-driven one that analyzes the steps within the utilization of big data. The theory ought to guide the analysis of big data through acquisition, processing, analytics and finally the interpretation of the data (Rai, 2016). Therefore, the scientific theory provides a reliable school of thought in terms of how the interrelation of the data can be done thus offer explanation and prediction.

Thirdly, the Classical Mathematical Theory of Statistics offers a highly diverse approach in terms of the description of what should be done when analyzing or examining data (Diaconis, 2016). The theory seeks to provide an interpretation of the patterns as the number of chances fluctuate. We should note that the theoretical framework postulates the decision on the models and hypothesis that can be developed before interacting with the data. Therefore, classical statistics provides the much-needed antidote for computing estimates and conducting tests based on the scientists' assumptions while solving the problems that may arise within the context of magical thinking. According to Kyburg (2014), the Classical Mathematical Theory of Statistics offers values such as the P-value and the standard error that are critical towards making interpretations that are valid and interesting.

3.0.   Framework

This section described the research design employed by the researcher to collect, analyze and interpret the informational data required to answer the study question. Since the study was a review, the researcher employed the systematic review which is defined as the research design that summarizes the outcomes or results of a number of primary studies (Ranganathan & Aggarwal, 2020). Systematic reviews utilize meta-analysis that is regarded as a statistical tool that

mathematically collates the outcomes of different research studies thus obtain a collective estimate of the intervention effect. It is important to note that a systematic review entails methodologically and comprehensively synthesizing literature that is focused entirely on a well-formulated study question (Siddaway, Wood, & Hedges, 2019). The design usually aims at identifying and synthesizing the available scholarly research on the study topic, conducting unbiased and reproductive search of evidence, and involves a meta-analysis.
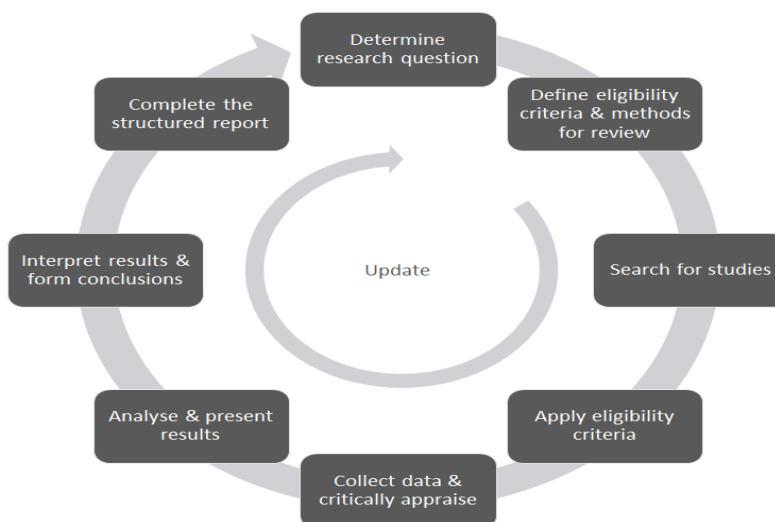

Fig 2: Systematic Review Process

According to Hanley and Winter (2013), systematic reviews are research methods that involve critically appraising, summarizing, and reconciling evidence. The technique entails comprehensively reviewing literature in a methodological manner using a pre-selected protocol thus minimizing bias thus synthesizing the retrieved informational data. This research design is characterized by having clearly stated objectives along with pre-defined inclusion and exclusion criteria for the studies. Also, systematic reviews have a reproducible and explicit methodologies, identify studies that meet the eligibility criteria, Ansari (2022) assess the validity of the study findings, and present and synthesize the characteristics as well as findings of the studies included in a systematic way (Ranganathan & Aggarwal, 2020).

Furthermore, the use of systematic reviews enabled the researcher to locate the relevant published and unpublished research studies that addressed the research questions while providing a systematic presentation and synthesis of the findings and characteristics of included research studies. Livinski at al. (2015) agree that the rationale for conducting systematic reviews involves making informed decisions, planning for future research agendas, establishing policies, preventing unnecessary studies and enabling the conducting of comparative effectiveness studies. Therefore, it is important to note the underlying differences between a systematic review and a narrative review in terms of their respective aims, structures and models that results in different outcomes within any given study (Hanley & Winter, 2013). Also, there is a reporting guide for systematic reviews that includes Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), and PRISMA + Health Equity Reporting (PRISMA-E).

The inclusion and exclusion criteria for the research studies to be included in the study was methodologically considered and developed. According to Meline (2016), searching for research studies across multiple databases requires a concrete eligibility criterion that enhances the identification, locations, and retrieval of informational data that addresses the research problem. This process specifies the studies that shall be included or excluded from the systematic review and is fundamental to the collection of defensible and rigorous data. Therefore, the researcher utilized an eligibility that was based on the following categories: study population, time period, type of intervention, study variables, quality of the research methodology and linguistic and cultural range (Patino & Ferreira , 2018). Using the titles and abstracts of the selected research studies, the researcher was able to include and exclude studies that met or did not meet the eligibility criteria.

4.0.   Review

This section includes a report of the systematic review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses or PRISMA statement. The PRISMA statement addresses the poor reporting of most systematic reviews by providing a checklist comprising of twenty-seven (27) items that are recommended to ensure quality reporting (Page, et al., 2021). The study searched from several databases including PubMed, JSTOR, ScienceDirect, Public Library of Science, BioMed Central, Cochrane Open Access and PLOS. The search from these databases resulted in a combined 180 hits related to the study topic and thus the researcher narrowed to 21 research studies that met the eligibility criteria. The selected studies were then analyzed based on the PRISMA checklist and the findings were summarized below based on the study objectives and hypothesis (Ansari 2022).

The concept of data analytics and its applications.

The objective sought to find out the conceptualization of data analytics and the major applications especially in healthcare. From the 21 research studies, a total of 19 described the concept of data analytics and various applications. For example, Wang and Alexander (2019) in their study *"Big Data Analytics in Healthcare Systems"* investigated the concept of big data in the healthcare system by comparing the various tools that are used to analyze data and their respective features that determine their performance. The study focused on the big data analytics with respect to the operational concept and the applications such as disease surveillance, supporting clinical decisions, managing population health, and controlling epidemics. However, the study was non-experimental thus relied on secondary data to answer the research questions and address the study problem. As result, the study provided the implications for future research while revealing the significance of data analytics in improving patient care and outcomes.

Understanding the application of data analytics in healthcare.

This objective sought to understand the various applications of data analytics in healthcare by investigating the specific case scenarios where the technique has been utilized within health systems. The search result of this objective from the selected studies was 10 with the articles comprising of both published and unpublished studies. Most of the studies highlighted the distinct areas within healthcare where data analytics were used. An example was the study by Batko and Ślęzak (2022) that revealed the move by health facilities towards the provision of data-based care that had significant benefits. In addition, Abbo and Suchithra (2021) provided a brief idea of the value added to health information through the use of data analytics and its processes. The study revealed the various applications of big data analytics in healthcare that included modelling for research and development of drugs, analysis of illness patterns and the tracking of diseases, and the efficient development of vaccines.

Determining the implications of data analytics in improving patient care.

This objective sought to understand the different implications of data analytics in healthcare. As a result, the search based on this objective resulted in 5 published studies that revealed the implications of data analytics in healthcare. An example was a study by Galetsi et al, (2020) that described big data analytics in the healthcare sector with regards to the underlying theoretical frameworks, techniques or methods and future prospects. The theoretical framework adopted by the study was the resource-based view theory that focuses on how resources related to big data can be utilized by organizations thus creating capabilities or values. As a result, the research presented various pragmatic scenarios that highlighted the advances that had been made possible due to the integration of data analytics in healthcare. The findings were that data analytics techniques helped healthcare personnel and scholars to make meaningful interpretations with regards to modelling, visualizations, and clinical analysis.

Establishing the challenges and opportunities of data analytics towards enhancing patient care.

The objective sought to establish the various challenges and opportunities that have been posited by the adoption and use of data analytics in healthcare. As a result, the researcher searched for studies that described the underlying problems associated with the application of data analytics within medical processes and the potential opportunities that exist with

regards to the use of data analytics techniques. The search resulted in the selection of 12 studies that provided the basis for establishing the challenges and opportunities of data analytics in healthcare. An example was the study by Shekarian et al. (2020) that revealed the need for the healthcare industry to harness the potential of data analytics towards improving administrative and patient care. By closing the gap in terms of research related to the use of data analytics in healthcare, the research provided insights into the effect of the concept in improving clinical operations (Dash et al., 2022).

Discussion, Conclusion and Future Implications

Based on the outcomes of the systematic review, it was evident that data analytics had a significant impact in the healthcare sector with regards to improving patient care. From the searched studies, big data as a concept is relevant to health systems as it had been found to improve patient outcomes. Using the PRISMA model to report the outcomes of the systematic review, the study addressed the selected research studies that included investigating the concept of data analytics and its applications, understanding the application of data analytics in healthcare, determining the implications of data analytics in improving patient care and establishing the challenges and opportunities of data analytics towards enhancing patient care (Dash et al., 2022).

Furthermore, the outcomes of the systematic review provided a basis for answering the research problem and declining the null hypothesis. Therefore, the study accepted the alternative hypothesis that stated that data analytics has significant impact towards improving patient care. This assumption was supported by findings such as various applications of big data analytics in healthcare including analysis of illness patterns and the tracking of diseases. The study suggested deeper research in this area thus provide an in-depth understanding of the implications.

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