Exploring Big Data Analytics in the healthcare sector: Considerations, need and challenges

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Abstract: Examining vast and complicated data sets to find patterns, correlations, and market shifts in order to improve business decisions and insights is known as Big Data Analytics. It entails the use of sophisticated methods and instruments to gather, process, and evaluate diverse, high-volume, and high-velocity information gathered from sources such as sensors, social media, and logs of transactions. Due to the rapid expansion of data and technological advancements, Big Data Analytics (BDA) has attracted a lot of attention from both academics and industry, especially in fields like healthcare. By increasing results for patients, enabling tailored medication, and boosting the precision of diagnostics, the combination of data from many sources and the application of cutting-edge analytical tools have the capacity to completely transform healthcare. Healthcare data, big data in healthcare organizations, and the uses and benefits of big data analytics in healthcare are all covered in the present research. It is also discussed how big data in healthcare has advanced technologically, including comparison of tools for Big Data Analytics. The discussion also includes the difficulties with big data analytics in healthcare settings.

Keywords: Big Data Analytics (BDA), Healthcare, Cloud Computing, Healthcare Information System, Natural Language Processing, Electronic Health Records.

1. Introduction

Large volumes of patient data are generated in the healthcare industry with the goal of lowering costs and enhancing the level of care. Finding patterns and trends in these data to solve challenges, is still a major difficulty when it comes to successful analysis (Ahmad et al., 2022). More complex big data analysis is now possible through the development of information and communication technologies, which have made it easier to share health information (Santos-Pereira, Gruenwald & Bernardino, 2022). It is widely recognized that the big data analytics is an effective method for extracting knowledge from both dispersed and centralized databases. The healthcare companies may create precise and individualized therapies while spotting potential savings by utilizing sophisticated statistical models and machine learning techniques. The big data analytics can also improve the efficiency in operations, cutting down on patient wait times and increasing the productivity of the medical personnel. As the big data analytics acceptance grows, it is critical to ensure the data security as well as privacy. By putting strong data governance mechanisms in place and following the standards for data handling, healthcare businesses may reduce the risks of breaches of data and cyber-attacks (Tao et al., 2019).

The healthcare sector is undergoing a change as a result of the availability of enormous volumes of medical big data. Sharing, analyzing, and processing this data using big data analytics has enormous promise for finding treatment trends and cutting medical expenses. Still, it is crucial to put patient privacy and security first, putting strong safeguards and legal frameworks in place to protect patient data (Nurgalieva, Callaghan & Doherty, 2020). Healthcare organizations must set up reliable systems for systematic big data analytics because any therapeutic delay brought on by privacy or security issues can have fatal outcomes. By enabling medical professionals to create

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more efficient treatments and improve patient outcomes, the use of big data analytics in healthcare signifies a substantial progress in enhancing the health of the community.

Large volumes of data from many sources, including smart gadgets, electronic clinical records, diagnostic imaging, and genomes data, are continuously presented to the healthcare sector (Ahmad et al., 2023). Such data is complicated and unstructured, making it difficult to manage and analyze. By facilitating effective processing and analysis, the technological developments like cloud computing, machine learning, and natural language processing have greatly enhanced the administration of large amounts of information related to healthcare. The COVID-19 pandemic has brought even more attention to the significance of the telemedicine and the digitization of the health records, which has led to a significant rise in the amount of data and higher demands on the healthcare sector to securely and efficiently handle such data. In order to protect critical patient data, efforts have therefore increased to create strong security measures and privacy protocols. A possible remedy is provided by the Block-chain technology, which provides a safe and decentralized method of data sharing and storing. Additionally, methods such as the differential privacy can be used to anonymize data, protecting patient privacy while enabling insightful big data research (Hassan, Rehmani & Chen, 2020). The use of the big data analytics in healthcare has been made possible by the technological improvements and the growing availability of the healthcare data. A thorough analysis that summarizes the current frameworks, investigates the ramifications, looks at the many applications, and evaluates the overall effects of the big data analytics in healthcare is urgently needed. The remaining part of this paper consists of a literature review, Big Data analytics in healthcare systems, BDA considerations in healthcare, the need of BDA in healthcare, issues of BDA in healthcare and finally a conclusion.

2. Related work and methodology

When this Comprehensive Literature Survey was being put together the authors discovered that numerous surveys have been conducted in the field of existing literature to examine the opportunities and difficulties related to big data analytics and the healthcare industry. They also noted that the fundamentals and difficulties of big data healthcare continue to be the key topics of current opinions. For example, Nambiar et al., (2013)'s study focused mostly on examining and analyzing the opportunities and problems related to the application of big data analytics in the healthcare industry. Following a discussion of the big data growth projections for 2015, the researchers presented spending information by region. Finally, they provided an insight on the healthcare system. Following a review of the existing research by (Raghupathi & Raghupathi, 2014), they provided a thorough analysis of the essential characteristics of big data, investigated an architectural framework, and clarified a number of potential applications in the healthcare industry. A comprehensive literature review covering the years 2008–2015 was conducted by Andreu-Perez et al., (2015). Their goal was to provide a comprehensive analysis of developments in big data biomedical and health analytics. A thorough analysis of the most recent developments in the application of big data across numerous healthcare fields was carried out by Luo et al., (2016). They highlighted the significant growth that has been seen during the past five years.

Islam et al., (2018) conducted a thorough literature study covering the years 2005–2018, concentrating on the possible applications of big data and data mining in healthcare analysis. Bahri et al., (2019) focused in their research on analyzing the numerous challenges and opportunities related to the application of big data analytics in the healthcare industry. Galetsi, Katsaliaki & Kumar, (2019) conducted a systematic evaluation of the literature in order to look into how data-driven approaches might improve the efficiency of healthcare as well as public health institutions. In their thorough review of the literature, Tandon et al., (2020) looked at how the Block-chain technology is being used in the medical field. Similarly, a comprehensive analysis covering two decades was released by Imran et al., (2021), providing insightful information about the use of big data analytics in the healthcare industry. Their work acts as a guide for the upcoming studies and advancements in this field.

Khanra et al., (2020) included a comprehensive literature review covering 2013–2020. Five different points to consider about the use of big data analysis in the healthcare industry were found

and examined by the researchers. A systematic examination of the literature on the big data analysis in data-driven enterprises was carried out by Ikegwu et al., (2022). Their research sought to investigate the status of the expertise in this field at the moment. Similarly, Zhang et al., (2022) looked into the main technologies used in the quickly growing virtual world industry, sometimes known as the Metaverse. They also looked at how the technology behind big data is being used in important fields like banking, e-health, conveyance, and business. Obviously, the present review study misses a precise focus on an integrated approach of both healthcare and big data while evaluating a large body of published work on Big Data Healthcare Analysis for the goal period of 2013–2025. Instead of examining big data and healthcare together, the existing research give ideas concerning each topic separately. In relation to the previous surveys, this study provides a more thorough examination of the present research gaps in the big data in the healthcare arena. This study looks at the framework for the big data in the healthcare industry, emphasizing the problems that come up in this setting. Furthermore, a thorough examination of the numerous applications of the big data in healthcare is carried out. In order to improve the thorough understanding of the topic, the advantages and uses of big data in the healthcare sector are also examined.

In order to enhance patient satisfaction and operational effectiveness, the Big Data Analytics (BDA) methodology in healthcare management uses cutting-edge tools to evaluate vast and diverse datasets, including data on finances, medical imaging, and electronic health records (EHRs). This entails gathering data from many sources, analyzing data that is structured and unstructured, and using analytical techniques such as prediction models and machine learning. Strategic planning, resource allocation, health sector policy, and enhancing patient care via disease identification and tailored medication are all impacted by the insights produced. The major segments of the methodology are (depicted in Figure 1):

- **Data collection and integration:** Compiling enormous volumes of data from outside resources, like government documents and insurance corporations, as well as insider databases like LIMS and EHRs.
- **Data processing:** Addressing the massive volume, the pace at which it is generated, and the variety of its forms (organized like test findings and unstructured like medical notes) are all part of the "3 Vs" of the big data.
- **Data analysis:** Using analytical methods to identify trends, connections, and insights is known as data analysis. This comprises:
  - **Descriptive analytics:** Knowing what has already occurred.
  - **Predictive analysis:** Applying historical data to predict future occurrences, like patient risk or admission rates, is known as predictive analytics.
  - **Prescriptive analysis:** Finding the appropriate course of action to accomplish a given result is known as prescriptive analytics.
- **Application of insights:** Using the analysis's findings to guide choices and enhance operations.

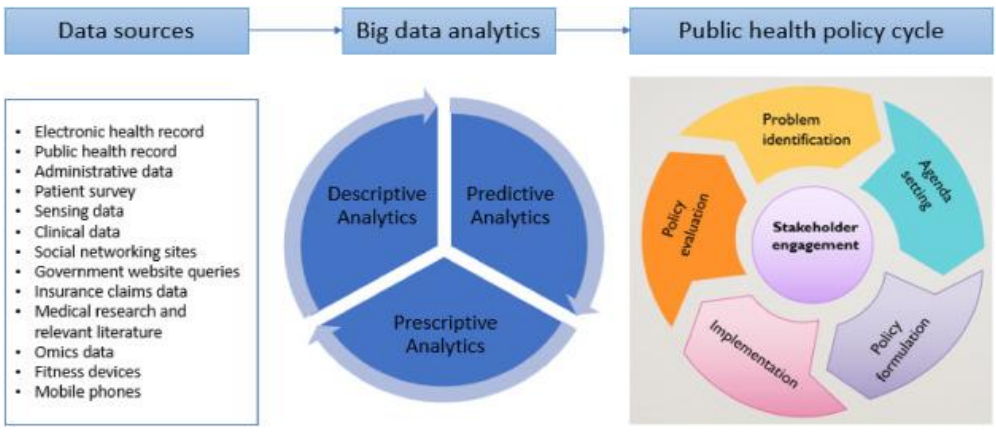

Figure 1. Big Data Analysis Methodology (According to our own research)

3. Big Data Analytics in healthcare systems

In this section the various Big Data features and a comparison of the tools used for analyzing big data will be disussed. Figure 2 illustrates Big Data in healthcare, its management and analysis:

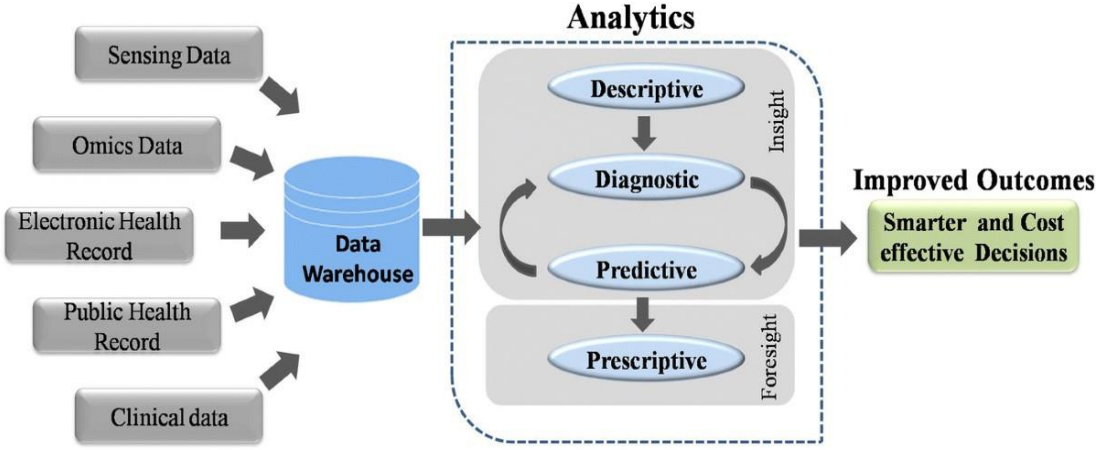

Figure 2. Big Data Analytics in healthcare management (According to our own research)

3.1. Big data features

Big data frequently has high values for Complexity, Volume, Velocity, Veracity, Value, Variety, Variability, and Sparseness, as Table 1 explains. Examples of the big data in healthcare might cover managing population health, support with clinical decisions, illness surveillance, and epidemic control, among other things. Early disease detection is one of the many advantages that the big data in healthcare may offer. Incorporating Big Data analytics into intelligent healthcare structures results in cutting-edge mobile and electronic health that boost productivity and reduce expenses.

Table 1. Features of Big Data

Feature	Description	Examples in Healthcare
Complexity	Hierarchies, linkages among items as well as recurrent structure of data.	Multipharmacy, multimorbidity.
Volume	Data size.	Medication plans, multiple conditions, and cohorts of patients.
Velocity	Data generation rates (batch, stream and infrequent interval).	Sensing as well as diagnostics transmitting patients' status and behaviors.
Veracity	Imprecise / untruthful data.	Clinicians' notes about patients' states, patients' review.
Value	Inherent value (often achieved via data mining).	Analyzing various patients' review and identifying the side effect of a drug.
Variety	Different formats and data types (numbers, text, images).	Clinical, medical, and omics data and pics from various patients under diverse situations.
Variability	Data change over time.	Health data via wearable sensor.
Sparseness	Low density of important information (due to null values, missing data, etc.)	Any missing data of patient feedback on progress and conditions.

Pharmacy technicians may employ predictive analytics to gain additional insight into the risks of particular medication-related issues, estimate pharmaceutical results, recognize patients who will benefit from pharmacist's measures and provide patient-specific treatments. From data collection and administration (including data storage, sharing, and privacy) to analytics (including data integration, data mining, and visualization), precision medicine works with data. The developments in biological technologies are making a vast amount of complex biomedical data accessible. Big Data Analytics, which encompasses fields of application including medical

informatics, sensor informatics, genomics, imaging informatics, etc., is necessary for exploiting these heterogeneous data.

Big Data is characterized as an information asset that is high in volume, velocity, and variety and that needs to be transformed into value using a particular technology and process. A group of information with large volume, high volatility, or high diversity is also known as "big data," and it necessitates new processing techniques to aid in decision-making, the discovery of novel phenomena, and process optimizations. Big Data needs novel methods to manage (collect, gather, process) its volume, velocity, and variety since it is too big for conventional data-processing systems and software tools to acquire, store, manage, and analyze.

When it comes to Big Data Analytics, Veracity is essential. Typographical inaccuracies, cryptic annotations, and abbreviations can all be found in personal medical records. In comparison to clinical data, which is gathered by qualified professionals in a clinical context, ubiquitous measurements may be performed in uncontrolled and less trustworthy settings. Predictions may be erroneous if uncontrolled, spontaneous data from social media is used. Furthermore, data sources can occasionally be biased. "Noise" data is a huge issue, particularly when they expand quickly. Heterogeneous outcomes from databases with varying levels of depth and quality raise the risk of erroneous findings and "biased fact-finding excursions." Two significant issues include biases brought on by the lack of randomization and poor data quality. Linking various databases and examining all of the current corresponding data are common ways to try to increase the value of big data. The process of turning unprocessed data into a comprehensible format is known as data pre-processing, and it frequently entails the following steps: 1) data cleaning; 2) data integration; 3) data transformation; 4) data reduction; and 5) data discretization. An essential stage in Big Data analytics is the pre-processing.

3.2. Comparison of tools for Big Data Analytics

Table 2 shows the comparison of tools for Big Data analytics in a very easy and convenient way.

Table 2. Comparison of tools

Tools	Database	Platforms	Advantages	Disadvantages
Google Big Query	Columnar database.	Open source and cloud-based framework.	Allows data to be replicated over diverse data centers.	Does not allow indexes.
Microsoft Windows Azure	Relational database.	Public cloud-based framework.	Permits users to make relational queries against structured, semi-structured and unstructured files.	The volume of the database is limited; it cannot handle large databases.
Hadoop	Non-relational database.	Open source and cloud-based framework.	Collects data with any structure such as Web logs.	Lacks technical support and security.
MapReduce	Non-relational database.	Open source and cloud-based framework.	Works well with semi-structured and unstructured data like visual and audio data.	Lacks indexing capability of modern database systems.
Jaql	Jaql is a query language for JavaScript object notation.	It is a proprietary query language.	Permits both structured and semi-structured data.	No user defined types; schema information only for possible values of a domain.

4. Considerations of Big Data Analytics in healthcare sector

The need for systems that provide efficient analytical tools has been steadily rising over the past few years. The analysis of massive amounts of data (Big Data, BD) also shows this trend. Companies are searching for methods to leverage the potential of big data to enhance their company's efficiency, competitive edge, or decision-making. Although big data is thought to have potential benefits for both public and commercial businesses, little is currently understood about how big data will really work in various kinds of corporations.

As previously stated, the disease-focused paradigm of healthcare administration has given way to a patient-focused approach globally in the last few years, even in value-driven healthcare delivery models. Healthcare Big Data must be managed and analyzed with the goal to satisfy this model's objectives and deliver efficient patient-centered care.

The proper use of big data is a common concern when it addresses data use in medical care. Large volumes of data have always been produced by the healthcare industry, and in the modern period, the advent of computerized medical records and the massive volumes of data released by patients on social media or provided by various kinds of sensors lead data streams to continuously expand. Massive volumes of data are also produced by the medical sector, comprising genomic information, healthcare records, medical imaging, and health-related behaviors. Health care agencies will be able to assist in public health management, disease monitoring, and medical decision-making through the appropriate use of the data. Medicinal data processing is a problem due to both the volume of data and the processing challenges (Singh, Kumar & Gupta, 2022).

Big Data is definitely different from the data sources that organizations have been using up to this point. As a result, companies need to take an alternate method to this kind of unstructured data. Organizations must first begin to view data as flows rather than stocks, which calls for the use of termed streaming analytics. The aforementioned characteristics necessitate the employment of new IT technologies that maximize the utilization of newly acquired data. The Big Data concept, which is inextricably linked to the vast expansion of data accessible to different companies or individuals, opens doors to insightful analyses and findings and facilitates the making of more precise judgments.

As a result, Big Data analytics show promise, particularly in terms of raising the standard of healthcare, saving lives, or cutting expenses. Healthcare providers along with the additional stakeholders in the healthcare industry will be able to offer more precise and helpful patient diagnoses, individualized treatment, tracking patients, preventive healthcare, support for medical studies and the health population, and higher-quality medical products and patient care while simultaneously lowering costs by deriving patterns and trends from this maze of established association rules (Figure 3).

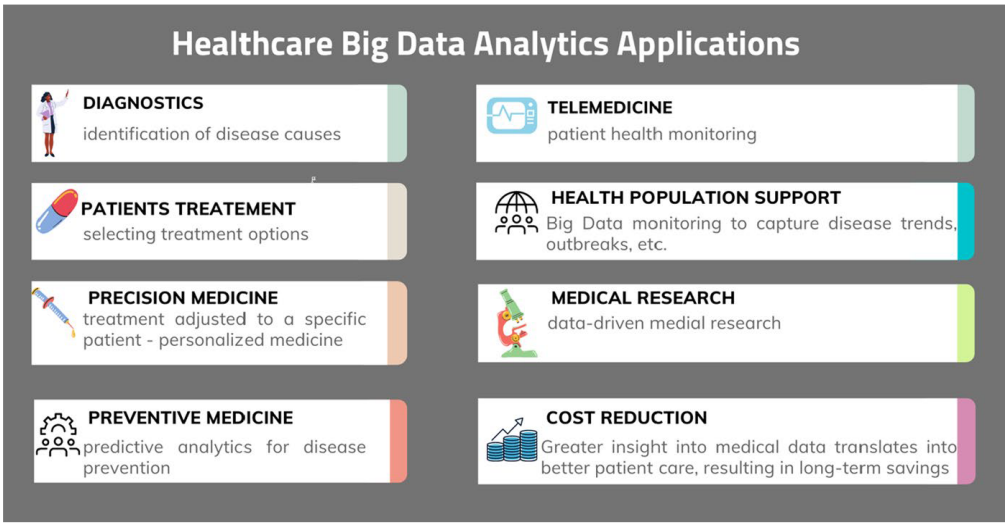

Figure 3. Applications of Big Data Analytics in healthcare (According to our own research)

Handling such a vast amount of data and using it to create data-driven decisions in a variety of fields is the primary problem with big data. Adjusting big data storage, analysis, display of analytical results, and inference based on them in a therapeutic setting is another significant difficulty in the wider context of healthcare information. The purpose of the healthcare data analytics systems is to better understand complicated data by describing, integrating, and presenting them in an appropriate manner (Figure 4). This would increase the effectiveness of gathering, storing, evaluating, and displaying large amounts of healthcare data.

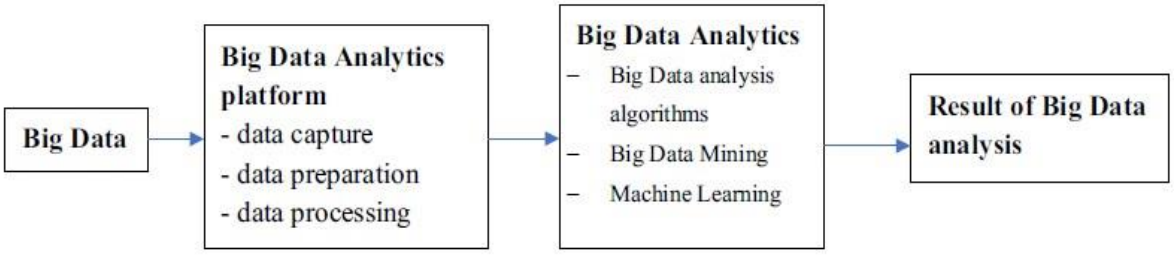

Figure 4. Big Data Analytics Process (According to our own research)

The combination and analysis of a vast amount of complex heterogeneous data, including biological data, telemedicine data (sensors, medical gadgets data), electronic health records data, and numerous omics (genomics, epigenomics, transcriptomics, proteomics, metabolomics, interactomics, pharmacogenetics, and deasomics), is referred by the term big data analytics in the fields of healthcare and medical science. Clinically speaking, the goal of the big data analysis is to enhance patients' health and well-being, make long-term predictions concerning their health, and carry out the right therapeutic interventions. In the end, data analytics is used in healthcare to enable a personalized medicine, or precision, tailored medicine, which involves tailoring the treatment to a particular patient.

The use and analysis of data in healthcare has advanced significantly. A major tenet of the policy of practically every nation is the widespread digitization and sustainability of this industry. For centuries, doctors' decisions about how best to treat their patients were based on their medical expertise. In the past few years, the importance of the Evidence-Based Healthcare has grown due to its association with the methodical examination of the clinical data and treatment decisions founded on the best available data. Big Data Analysis is anticipated to lower operating costs and enhance the quality of existence in the healthcare industry. Organizations can enhance and deepen their comprehension of the information found in data by utilizing big data analytics. Additionally, it aids in locating the information that offers valuable perspectives for both present and future choices.

5. The need for Big Data Analytics in healthcare

The growing amount of big data in the healthcare industry is causing a slow increase in the number of BDA apps. Big data in healthcare can come from a variety of sources, including complex and varied patient findings, comprising demographics, medical histories, and test results. The data may be unstructured (such as a compilation of observations) or structured (such as genotype, phenotype, or genomics data) (e.g., notes from physicians, prescriptions, or medical imaging). Generating and collecting excellent real-time data is often required when adopting data in medical. Substantial insights gleaned from massive quantities of data enable decision-makers in the medical field to take effective action. The health industry is undergoing a big data revolution as a result of the massive increase in data collected through wearable sensors, registries, and EHRs. Numerous advantages result from this vast amount of data, including improved quality of living, the detection and treatment of illnesses, and the system for delivering healthcare services. Large, diverse, and rapidly growing amounts of big data are produced in the healthcare industry. Big data in healthcare necessitates real-time data analysis along with non-uniform data. Healthcare companies are using technologies to stay current since big data is changing quickly:

- Identifying patient-centered symptoms with predictive modeling;
- Early illness or medical issue detection and prevention;
- A lot of research and development to treat illnesses;
- Electronic health record (EHR) usage and promotion;
- Using data-driven insights to empower and engage patients;
- Using predictive analytics to find and reduce patient risks;
- The creation of alerts for immediate care;
- Analysis of health data for distributing resources and optimization;
- Reducing fraud and improving data security;
- Cutting down on pointless ER or hospital visits;
- Combining medical imaging with additional diagnostic methods to improve patient outcomes;
- Astute and improved personnel management;
- Potential for health care providers to pursue ongoing education and growth;
- Predictive analysis and therapy for reducing suicide and harming oneself;
- Contribute to the creation of novel ideas;
- Making decisions based on data to cut management and administrative expenses.

The preceding list of possible uses for big data analytics in healthcare is not all-inclusive. Nonetheless, it offers a thorough rundown of some of the more significant applications. When these advantages are realized, big data-driven healthcare businesses will be equipped to compete with their competitors in day-to-day operations. The Big Data-driven health system performance structure which comprises sub-health-domains, is shown in Figure 5. Notably, the cooperation from a range of stakeholders, especially physicians, data scientists, and legislators, is necessary for the effective application of big data analysis in healthcare. The integration of data from many sources and the creation of algorithms that can yield useful insights are made possible by this alliance. When utilizing patient data for research, it's also critical to make sure that ethical issues are taken into regard. Establishing precise rules and procedures for data exchange and informed permission can help.

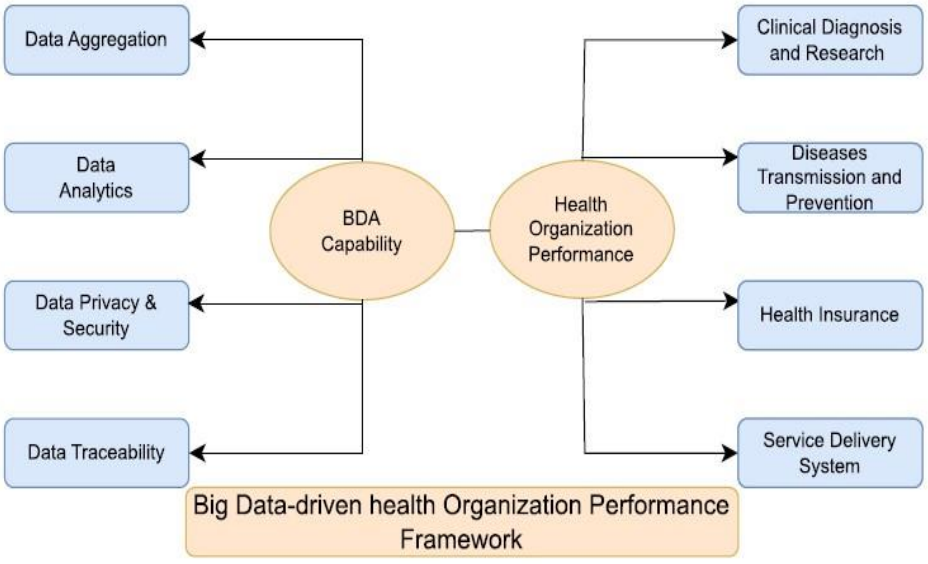

Figure 5. Performance framework for health organizations powered by Big Data
(According to our own research)

6. Challenges of Big Data Analytics in healthcare

Although there are many advantages to using big data analytics in healthcare, there are also certain challenges in doing so. Three primary categories of issues have been discovered by the assessment of pertinent literature: management, process, and data issues. A quick description of the most often mentioned challenges associated with this area is provided.

6.1. Data quality

For reliable research and forecasts, healthcare data quality is essential. Yet, a number of reasons, including human error, antiquated technology, or poor data management techniques, sometimes result in incomplete, erroneous, or conflicting healthcare data.

6.2. Data integration

Since healthcare data is frequently kept in several different systems, it can be challenging to properly integrate and evaluate them. A strong data integration platform and a defined data format are necessary for integrating data from various sources.

6.3. Data privacy and security

In order to adhere to laws like HIPAA, important medical data that includes private information need to be protected. A strong security architecture is necessary when employing big data in healthcare to guard against theft or illegal exposure of information related to patients.

6.4. Resource constraints

Big Data analytics implementation in the healthcare industry necessitates a large investment in staff, software, and technology. The use of big data analytics within the medical field may be hampered by a shortage of resources.

6.5. Skills and expertise

Healthcare Big Data implementation calls for knowledge and proficiency in a number of fields, including software development, machine learning, data science, and analysis. To develop the required skills, healthcare institutions could have to spend money on training or bring on new hires.

6.6. Data governance

Maintaining data quality, protecting privacy of patients, and ensuring regulatory compliance all depend on competent healthcare data governance. Roles and duties must be clearly defined, data management rules and regulations must be followed, and an environment for data exchange must be established.

6.7. Cost

Because Big Data healthcare requires infrastructure, technology, software, and staff members, it can be expensive to set up. Establishing a strong Big Data platform may require large financial investments from the healthcare institutions.

6.8. Ethical issues

Big Data in the healthcare sector raises ethical concerns about the disclosure of patient data for business purposes or research, potential prejudice or discrimination, and the requirement to inform patients about the usage of their data.

7. Conclusion

7.1. Summary of findings

Big Data Analytics will revolutionize healthcare by overcoming the constraints of conventional data analytics, which cannot handle big data in healthcare systems. Big data analytics has the capability to revolutionize monitoring of diseases, epidemic control, clinical decision

assistance, management of public health, and more. Big Data Analytics has the capacity to improve healthcare and have worldwide impacts. The present results show that big data analytics in healthcare faces major obstacles due to the vast volume and complexity of the healthcare data. It might be challenging to extract an insightful conclusion from high-dimensional, distorted, and unstructured data. Creating dependable and trustworthy big data healthcare architectures that put patient privacy and data security first is essential to overcoming these obstacles. Additionally, this research has brought attention to the necessity of optimizing systems for big data in order to increase the overall quality of life, save costs, and strengthen the results for patients.

7.2. Limitations

Big Data Analysis in healthcare has several drawbacks, such as significant privacy and security concerns, problems with data quality and integration from various sources, and the expensive installation and specialized staffing costs. Inadequate standardization, data bias, scalability and storage issues, and the requirement for real-time processing and advanced analytical tools to manage the volume and complexity of data are additional significant restrictions.

7.3. Future research directions

Big Data Analysis for healthcare is expected to lead to greater individualized treatment, better patient outcomes, and more effective operations in the future by using developments like AI, predictive analytics, and real-time tracking. This results in a more proactive, accurate, and economical healthcare system by utilizing enormous databases to forecast diseases, manage medical facilities, and customize treatment regimens. Improved public health management, real-time medical monitoring through IoT, and improved medication discovery are important areas of progress. Future studies on the application of big data in healthcare facilities will focus on defining the tactics used by different healthcare organizations and institutions to market and execute these solutions, in addition to the advantages they derive from using big data analysis and the perceptions of those in this field.

Author contributions

Conceptualization: K.S., V.S. and Y.S.; Data Curation: K.S. and Y.S.; Project administration: K.S., V.S. and Y.S.; Supervision: K.S. and V.S.; Validation: V.S. and Y.S. ;Writing—original draft: K.S. and V.S.; Writing—review and editing: K.S. and V.S. All authors have read and agreed to the published version of the manuscript.

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REFERENCES

Ahmad, H.F., Rafique, W., Rasool, R.U. et al. (2023) Leveraging 6G, extended reality, and IoT big data analytics for healthcare: A review. *Computer Science Review*. 48(C), 100558. https://doi.org/10.1016/j.cosrev.2023.100558.

Ahmad, I., Asghar, Z., Kumar, T. et al. (2022) Emerging technologies for next generation remote health care and assisted living. *IEEE Access*. 10, 56094–56132. https://doi.org/10.1109/ACCESS.2022.3177278.

Andreu-Perez, J., Poon, C.C.Y., Merrifield, R.D. et al. (2015) Big data for health. *IEEE Journal of Biomedical and Health Informatics.* 19(4), 1193–1208. https://doi.org/10.1109/JBHI.2015.2450362.

Bahri. S., Zoghlami. N., Abed. M. & Tavares, J.M.R.S. (2019) BIG DATA for healthcare: A survey. *IEEE Access*. 7, 7397–7408. https://doi.org/10.1109/ACCESS.2018.2889180.

Galetsi, P., Katsaliaki, K. & Kumar S. (2019) Values, challenges and future directions of big data analytics in healthcare:Asystematic review. *Social Science Medicine.* 241, 112533. https://doi.org/10.1016/j.socscimed.2019.112533.

Hassan, M.U., Rehmani, M.H. & Chen, J. (2020) Differential privacy techniques for cyber physical systems: A survey. *IEEE Communications Surveys & Tutorials*. 22(1), 746–789, 1st Quart. https://doi.org/10.1109/COMST.2019.2944748.

Ikegwu, A.C., Nweke, H.F., Anikwe, C.V. et al.(2022) Big data analytics for data-driven industry: A review of data sources, tools, challenges, solutions, and research directions. *Cluster Computing.* 25(2), 3343–3387. https://doi.org/10.1007/s10586-022-03568-5.

Imran, S., Mahmood, T., Morshed, A. & Sellis, T. (2021) Big data analytics in healthcare - A systematic literature review and roadmap for practical implementation *IEEE/CAA Journal of Automatica Sinica*. 8, (1), 1–22. https://doi.org/10.1109/JAS.2020.1003384.

Islam, M., Hasan, M., Wang, X., et al. (2018) A systematic review on healthcare analytics: Application and theoretical perspective of data mining. *Healthcare*. 6(2), 54. https://doi.org/10.3390/healthcare6020054.

Khanra, S., Dhir, A., Islam, A.K.M.N. & Mäntymäki, M. (2020) Big data analytics in healthcare: A systematic literature review. *Enterprise Information Systems.* 14(7), 878–912. https://doi.org/10.1080/17517575.2020.1812005.

Luo, J., Wu, M., Gopukumar, D. & Zhao, Y. (2016) Big data application in biomedical research and health care: A literature review. *Biomedical Informatics Insights*. 8, S31559. https://doi.org/10.4137/BII.S31559.

Nambiar, R., Bhardwaj, R., Sethi, A. & Vargheese, R. (2013) A look at challenges and opportunities of big data analytics in healthcare. In *2013 IEEE International Conference on Big Data, 06-09 October 2013, Silicon Valley, CA, USA*. IEEE. pp. 17-22. https://doi.org/10.1109/BigData.2013.6691753.

Nurgalieva, L., Callaghan, D.O' & Doherty G. (2020) Security and privacy of mHealth applications: A scoping review. *IEEE Access*. 8, 104247–104268. https://doi.org/10.1109/ACCESS.2020.2999934.

Raghupathi, W. & Raghupathi, V. (2014) Big data analytics in healthcare: Promise and potential. *Health Information Science and Systems.* 2(1), 1–10. https://doi.org/10.1186/2047-2501-2-3.

Santos-Pereira, J., Gruenwald, L. & Bernardino, J. (2022) Top data mining tools for the healthcare industry. *Journal of King Saud University - Computer and Information Sciences*. 34(8), 4968–4982. https://doi.org/10.1016/j.jksuci.2021.06.002.

Singh, K., Kumar, A. & Gupta, M.K. (2022) Applications and analytics of bioinformatics, healthcare informatics for modern healthcare system. *Romanian Journal of Information Technology and Automatic Control*. 32(4), 69-76. https://doi.org/10.33436/v32i4y202206.

Tandon, A., Dhir, A., Islam, A.K.M.N. & Mäntymäki, M. (2020) Blockchain in healthcare: A systematic literature review, synthesizing framework and future research agenda. *Computers in Industry.* 122, 103290. https://doi.org/10.1016/j.compind.2020.103290.

Tao, H., Bhuiyan, M.Z.A., Rahman, M.A., et al. (2019) Economic perspective analysis of protecting big data security and privacy. *Future Generation Computer Systems.* 98, 660–671. https://doi.org/10.1016/j.future.2019.03.042.

Zhang, H., Lee, S., Lu, Y. et al. (2022) A survey on big data technologies and their applications to the metaverse: Past, current and future. *Mathematics*. 11(1), 96. https://doi.org/10.3390/math11010096.

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