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Fusion of Big Data and HealthCare: A Review

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ABSTRACT: The rapidly expanding field of Big Data has started to play a pivotal role in the evolution of healthcare practices and research. It has provided tools to accumulate, manage, analyze, and assimilate large volumes of disparate, structured, and unstructured data produced by current healthcare system. Research identifies the recent surge in healthcare data as the key for improving health outcomes and reducing the ever increasing healthcare costs. The rise of big data, however, also raises challenges in terms of privacy, security, data ownership, data stewardship and governance. This paper discusses big data as a concept and various challenges it brings along with itself. This paper also provides an insights overview of the Big Data Analytics implementations and decision making in healthcare in today's era.

KEYWORDS: Big Data, Healthcare, Stakeholders, Challenges, Opportunities

I. INTRODUCTION

An era of open information in healthcare is now under way. We have earlier experienced a decade of breakthrough in digitizing medical records, as pharmaceutical companies and other organizations aggregate years of research and development data in electronic database. The government and other public stakeholders have also accelerated the move toward clarity by making decades of stored data accessible, searchable, and actionable by the healthcare sector as a whole. Healthcare stakeholders now have approach to promising new threads of knowledge. This information is a form of "big data", so called not only for its sheer volume but for its complexity, variety, and opportuneness. Pharmaceutical-industry experts, payers, and providers are now onset to analyze big data to obtain insights. They could altogether help the industry address problems akin to variability in healthcare quality and intensify healthcare speed. To enhance the quality of healthcare by minimizing the costs, it is mandatory that the data generated should be analyzed adequately to answer new challenges.

Data has the potential to revolutionize healthcare **-** it is not just about processing huge datasets, but about making data 'hypothesis generating' rather than 'hypothesis driven' [11]. The power of Big Data is that it can be executed promptly and its effects can be felt from both micro and macro levels. Big Data analytics have the potential to help make comprehensive enhancements in organizations. Regulatory compliance is a top priority, but data analytics allow us to go beyond compliance and begin to fully understand the organization as a whole, including where to focus new investments without taking the emphasis off patient care quality [10].

A. *Big Data*:

Big data is an all-encompassing term for any collection of data sets so enormous and convoluted that it becomes challenging to process using on-hand data management tools or traditional data processing software. Big data usually includes data sets with sizes beyond the ability of frequently used software tools to apprehension, curate, manage and process the data within a sustainable elapsed time.

Analytics when practiced in the context of big data is the process of examining large amounts of data, from a variety of data sources and in different formats, to deliver the insights that can enable decisions in real or near real time. Various analytical concepts such as data mining, natural language processing, artificial intelligence and predictive analytics can be employed to analyze, conceptualize and visualize the data. Big data analytical approaches can be employed to recognize intrinsic patterns, correlations and oddity which can be exposed as an outcome of integrity vast amounts of data from different data sets.

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Big data analytics has derived from two well-defined concepts – big data and analytics. Together it exemplify a new information arrangement approach that has been designed to derive previously undeveloped intelligence and intuition from data to address many new and vital questions within the health sector, it yield stakeholders with new intuition that have the potential to advance personalized care, improve patient outcomes and avoid futile costs. Big Data Analytics is new information management approach and set of capabilities for exposing additional value from heath information [8]. The size of digital data in 2011 is roughly 1.8 Zettabytes (1.8 × 10bytes) and they assert that the supporting network infrastructure has to manage 50 times more information by year 2020 [1]. This tendency is due to the fact that multiscale data increasing, particularly with the new high–throughput sequencing platforms, real-time imaging, and point of care devices, as well as wearable computing and mobile health technologies. They yield genomics, proteomics and metabolomics, as well as long-term continuously physiological features of an individual [2].

It can be classified into two types:
Structured data: For the most part, structured data cite to information with a high degree of organization, such that involvement in a relational database is smooth and promptly searchable by simple, unequivocal search engine algorithms or other search operations.
Unstructured data: Unstructured data is a universal label for illustrate data that is not contained in a database or some other type of data structure. Unstructured data can be textual or non-textual. Textual unstructured data is generated in media like email messages, PowerPoint presentations, Word documents, collaboration software and instant messages. Non-textual unstructured data is generated in media like JPEG images, MP3 audio files and Flash video files.

Healthcare organizations are depending on big data technology to apprehension all of these information about a patient to get a more complete view for intuition into care coordination and outcomes-based reimbursement models, health management, and patient commitment.

B. *Deviation in Health Care*:

As in the modern world Health hazards given a warning for every individual's health and as there is more globalisation more and more diseases transfer from diverse regions from across the globe which keeps the world in alarm state. In healthcare sector, the information stored in health database has intensified over the past ten years, prominent it to be considered big data. This industry incites huge amounts of data driven by record keeping and patient care [3]. This enormous quantity of data influence the promise of supporting an extensive range of medical and healthcare functions, including clinical decision support, sensor-based health condition and food safety monitoring, disease surveillance, and population health management, etc. However, to satisfy the above-mentioned health services, health information needs to be reachable and feasible to everyone involved in the healthcare sector. Many solutions for the extant diseases are yet to be found as well as the R&D department of different nations are trying to find distinct solutions and for these all information a refined and organized storage environment is a must and should requirement [4]. In addition, if pharmaceutical developers could assimilate population clinical data sets with genomics data, this development could ease those developers gaining approvals on more and better drug therapies more quickly than in the past and more importantly, expedite distribution to the right patients [3]. New intuition can also help organizations more effectively to communicate with healthcare consumers and encourage healthier lifestyles.

II. BIG DATA IN HEALTHCARE

Big data in Healthcare is the drive to capitalize on growing patient and health system data availability to develop healthcare innovation. By making smart use of the ever-increasing amount of data available, we can find new insights by re-examining the data or combining it with other information. In healthcare this means not just mining patient records, medical images, bio banks, test results, etc., for insights, diagnoses and decision support advice, but also continues analysis of the data streams produced for and by every patient in a hospital, a doctor's office, at home and even while on the move via mobile.

Current medical hardware, monitoring everything from vital signs to blood chemistry, is beginning to be networked and connected to electronic patient records, personal health records, and other healthcare systems. The emerging data

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stream is observed by healthcare professionals and healthcare software system. This allows the former to care for more patients, or to involve and guide patients earlier before an aggravation of their (chronic) diseases. At the same time data are provided for bio-medical and clinical researchers to mine for patterns and correlations, triggering a process of "data-intensive scientific discovery", building on the traditional uses of empirical description, theoretical computer-based models and simulations of complex phenomena [5].

At present, medical domain is broadly using new technologies such as capturing devices, sensors, and mobile applications. More medical knowledge or discoveries are being assembled in a constant flow. As a result, medical images such as X-Rays, CT and MRI-scan results, laboratory records, surgery and implants results, genomic information, medication information, insurance details, national health register data, medicine and surgical instruments expiry date identification based on RFID data are continuously being included into healthcare databases. Hence, the volume of healthcare is growing exponentially. However, this vast amount of complex data yields many opportunities (e.g., quality services, reducing healthcare cost, detecting uncommon disease pattern, etc.) for us and that can be concluded through adequate analysis has the potential to improve care, save lives, and lower costs by discovering associations and understanding patterns and trends within the data [6].

While most data is stored in hard copy form, due to the overflow of data, the current trend is towards swift digitization of these large amounts of data. Driven by imperative requirements and the potential to improve the quality of healthcare delivery meanwhile reducing the costs, these immense quantities of data hold the commitment of supporting a wide range of medical and healthcare functions, including among others clinical decision support, disease surveillance, and population health management [3]. Healthcare organizations can leverage data to:

- gain better understanding of actual costs and outcomes
- identify areas where they have the most gains from improvements
- rigorously track performance over time [7]

A. *Sources of Healthcare Big Data*:

By definition, big data in healthcare refers to electronic healthcare data sets so huge and complex that they are challenging to manage with traditional software and/or hardware; nor can they be managed with traditional or common data management tools and methods [3]. The big data that healthcare organizations need to collect and analyze may come from hospitals, ambulatory care facilities, wellness centers, referral networks, labs and imaging centers, research and other non-traditional data sources [7].

It is true that health data are copious and heterogeneous. The reason is that they come from different internal and external sources that are available at many locations (geo-graphic as well as different healthcare provider's sites) in diverse legacy and other applications (transaction processing applications, databases, etc.). Further, the data may be in multiple formats, e.g., flat files, .csv, relational tables, ASCII/text, etc. Some very common examples of the internal and the external sources of health data are listed below.

External Sources

Web and Social Media Data: Data from specific health cites, Facebook, Twitter, LinkedIn, blogs, and the like belong to this source.

Machine to Machine Data: This includes readings from remotesensors, meters, and other vital sign devices.

Internal Sources

Biometric Data:It contains finger prints, genetics, hand- writing, retinal scans, x-ray and other medical images, blood pressure, pulse and pulse-oximetry readings, and other similar types of data.

Human-Generated Data:Medical data collected from Electronic Medical Records, physician's notes (paper documents) and interpretations, interviews with the patient, etc. are examples of human-generated data. These are usually unstructured or semi-structured or both.

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III. BIG DATA ANALYTICS IN HEALTHCARE

The enduring digitization of health records together with the interoperable electronic health record (EHR), presents new opportunities to investigate a myriad of clinical and administrative questions. There is potential to layer Big data analytics-type applications, in a privacy-protective manner, on top of the foundational health IT infrastructure to derive value that might not otherwise be found [8]. Big data analytics applications in healthcare take advantage of the explosion in data to extract intuitions for making improved informed decisions and as a research category are referred to as, no surprise here, big data analytics in healthcare. When big data is synthesized and analyzed—and those preceding associations, patterns and trends revealed—healthcare providers and other stakeholders in the healthcare delivery system can develop more thorough and astute diagnoses and treatments, resulting, one would expect, in higher quality care at lower costs and in better outcomes overall. The potential for big data analytics in healthcare to lead to better outcomes exists across many scenarios, for example: by analyzing patient characteristics and the cost and outcomes of care to identify the most clinically and cost compelling treatments and offer analysis and tools, thereby influencing provider behaviour; applying advanced analytics to patient profiles (e.g., segmentation and predictive modelling) to proactively determine individuals who would benefit from preventative care or life- style changes; broad scale disease profiling to determine predictive events and support prevention initiatives; collecting and publishing data on medical procedures, thus helping patients in deciding the care protocols or regimens that offer the best value; classifying, predicting and minimizing fraud by implementing advanced analytic systems for fraud detection and checking the accuracy and firmness of claims; and, implementing much nearer to real-time, claim authorization; creating new revenue streams by accumulating and synthesizing patient clinical records and claims data sets to provide data and services to third parties, for example, licensing data to assist pharmaceutical companies in identifying patients for admittance in clinical trials. Many payers are developing and deploying mobile apps that help patients manage their care, locate providers and improve their health. Via analytics, payers are able to monitor adherence to drug and treatment regimens and detect trends that lead to individual and population wellness benefits [3].

Some more areas in which intensify data and analytics can yield great results include:

- Identifying treatments, programs and processes that are not conveying demonstrable benefits or are costing too much, and then determining how to change them with more efficient and effective options.
- Lowering readmissions by identifying environmental or lifestyle factors that increase risk or trigger detrimental events, and adjusting treatment plans accordingly.
- Building sustainability into a health system by bringing clinical, financial and operational data together to analyze resource utilization, productivity and throughput.
- Attracting the best and brightest clinicians, who can help to build and maintain an organization's reputation by offering innovative health IT systems and mobile technologies that enable collaboration and easy, secure remote access to patient records [7].

All healthcare constituents- members, payers, providers, groups, researchers, governments, etc.- will be jolt by big data, which can predict how these players are likely to behave, encourage enticing behaviour and minimize less desirable behaviour [9].

IV. THE V'S IN HEALTHCARE

To recognize these benefits, however, new approaches and technologies are required. Organizations need new analytics solutions and robust infrastructures that can handle big data and generate results expeditiously [10].

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Volume: According to Health Catalyst, healthcare firms with over 1,000 employees store over 400 terabytes of data per firm (reported in the year of 2009), which qualifies healthcare as a high-data volume industry, despite the real-time streams of web and social media data. The information stored in the healthcare scenario includes personal patient data, medication history, radiology reports, X-Ray images, ECG reports, human genetics and population data genomic sequences, etc. Newer forms of big data, such as 3D imaging, genomics and biometric sensor readings, are also sustaining this exponential growth [13]. Healthcare organizations are compiling more data and they intend to analyze data more thoroughly than since [10].

Velocity: Data evolve very rapidly and the generated unusual quantity of data needs to be stored, transmitted, and processed quickly. Velocity of mounting data increases with data that represents regular monitoring, such as multiple daily diabetic glucose measurement, blood pressure readings and EKGs, etc. This is crucial in healthcare for areas such as clinical decision support, where access to up-to-date information is vital for correct and timely decision-making and elimination of errors. Without current data, automated decisions cannot be trusted [9]. Specialized companies such as financial traders have already swing systems that cope with fast moving data to their interest.

Variety: Performance with only one peculiar type of data can never determine the efficiency. Variety suggests that data may be structured (e.g. Relational data), unstructured (e.g. Word, PDF, Text, Media Logs, etc.) or semi-structured (e.g. XML data, csv: comma separated value) [6]. This is challenging as the data is both comprehensive and is not structured. Therefore, handling such data efficiency to get value out of it is a big challenge.

*Veracity:*The term relates to quality, relevance, predictive value, and meaningof data. Specifically, this feature ensures the degree of truststo the leader of an organization to make decision. So, establishing the right correlation among these qualities in big data is very important for the business future. Veracity in data analysis is rather a challenging task than managing other characteristics like volume and velocity [6].

V. BIG DATA LIFE CYCLE

The Big Data Life Cycle involves 5 steps:

Data collection (acquisition): Big data does not arise out of a vacuum. It is recorded from several data-generating sources. This phase concerns with collection of data from various data sources and stores them in system like Hadoop Distributed File System (HDFS). Data can be anything such as case history, medical images, social logs, sensor data etc.

Data cleaning:The information collected from various sources may not necessarily be in a format ready for analysis. There may exist inconsistencyin data and much of the data may be of no interest. So, it is necessary to filter out and compress them by orders of magnitude. Forexample, electronic health records captured from hospitals comprise transcribed dictations from several physicians, image data such as X-rays, and structured data from sensors and measurements.

Data aggregation: This phase first aggregates the data of different formats and finally represents them into a commonformat. However, any data regardless of whether structured, semi-structured, and unstructured should be first purposely analyzed to accept or reject. For example, medical data consist of mostly unstructured data such as hand-written physician notes.

Data modelling and analysis: This deals with the methods for queryingand miningbig data in order to design predictive model for unseen data, and the designed model certainly performs analysis on the classified data. Forexample, Government may require a list of malnourished childrenin a location. In this respect, it is first crucial to gather family-wise details of the location. Then, we must identify the children whose family are below poverty line. These data are now processed to generate the health report of children.

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Data delivery:It involves generation of report based on modelling of data. For example, a report comprising malnourished children at a particular location can be made to take appropriate precaution. So, it helps the government to take necessary measures to avoid any further complications.

VI. STAKEHOLDERS

The various stakeholders in healthcare industry have different expected incentives and hopes from Big Data which can be summarized as follows:

Patients want their everyday use of technology to flow seamlessly into their medical care. Some want to comparison shop for medical treatment as they do for consumer products. People wants customer-friendly service, one-stop shopping, and better coordination of care between themselves, caregivers and various providers, with an ultimate goal of error-free, compassionate and effective care.

Providers want real-time access to patient, clinical and other related data to support enhanced decision-making and facilitate effective, efficient and error-free care. They want technology to be a translucent tool, not an encumbrance.

Researchers want new tools to enhance the quality and quantity of workflow – e.g., predictive modelling, statistical tools and algorithms that enhance the design and results of experiments and provide a better understanding of how to develop treatments that meet unmet needs while successfully navigating the regulatory approval and marketing process.

Pharmacy companies want to better understand the causes of diseases, find more targeted drug candidates, and design more successful clinical trials to avoid late failures and market safer and more effective pharmaceuticals. Once in the market, they want rigorous formulary and remuneration information to customize their marketing efforts, as well as less costly post-marketing surveillance.

Medical device companies, many of which have been collecting data for some time from hospital and home devices for safety monitoring and detrimental event prognosis, are beginning to wonder what to do with this data, and how to integrate it with old and new forms of personal data [15].

VII. OPPORTUNITIES WITH HEALTHCARE BIG DATA

Due to digitization and interconnection of healthcare data, compelling benefits are achieved today. As for the HealthCare environment from a small Single-Physician's office to a Multi-Speciality service provider's and a local hospital to a Multi Group Hospital networks all have the same problem of getting the accurate data and storing of the available data that generates every day. From the point of detecting the diseases to the treatment etc., everything is to be stored and maintained effectively. It helps in finding the diseases in their early stages and can find the logical solutions for the early treatment and the future consequences. There arise a hundred and one questions with request to the Big data analysis, certain outcomes and predictions go further to solve many situations with critical cases such as stay period of a patient, MRSA, disease, possible combinations, advancement in the state of treatment, factors involved, etc., with the help of big data analysis the inefficiency and waste can be reduced to a maximum extent [6]. Some of the major benefits (mainly achieved through analytics) are detailed below as much as possible for showing more practical insights.

Clinical operations: The health data set is capable to provide comparative efficacy research to decide more practical and clinically essential approaches. This also suggests the cost-effective ways to diagnose and treat patients. Clinical decision support system to enhance the efficiency and quality of operations; i.e., providing real-time information to emergency technicians, nurses and doctors to improve triage, diagnosis, prescription and other medical errors [Pune university].

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*Research and Development:*1) Predictive modelling to lower attrition and produce a leaner, faster, more targeted R&D pipeline in drugs and devices; 2) statistical tools and algorithms to improve clinical trial design and patient recruitment to better match treatments to individual patients, thus reducing trial failures and speeding new treatments to market; and 3) analyzing clinical trials and patient records to identify follow-on indications and discover adverse effects before products reach the market [3].

Public Health: On analyzing disease patterns, tracking disease surge and its transmission ensures to improve public health-surveillance and speed-response. Example includes faster development of more accurately targeted vaccines, e.g., choosing the annual influenza strains. Turning large amounts of data into actionable information that can be used to identify needs, provide services, and predict and prevent crises, especially for the benefit of populations [3].

Genomic analytics: It assists to execute gene sequencing more efficiently and cost effectively. Genomic analysis must be a part of the regular medical-care decision process and the growing patient medical record [6]. Utilize high throughput genetic sequences to capture organism DNA sequences and perform genome-wide association studies for human disease and human microbiome investigations [16].

*Patient profile analytics:*Apply advanced analytics to patient profiles (e.g., segmentation and predictive modelling) to identify individuals who would benefit from proactive care or lifestyle changes [6].

Fraud detection: Analyze a large amount of claim requests rapidly by using distributed processing plant form (e.g., MapReduce for Hadoop) to reduce fraud, waste, and abuse, such as hospital's overutilization of services, or identical prescriptions for the same patients filled in multiple locations.

VIII. CHALLENGES IN HEALTHCARE

Along with the benefits that healthcare has been leveraging from big data, there is certain issues and challenges that act as blockade in successful implementation of big data for healthcare and prove to be a hindrance in proper and maximum extraction in the terms of advantages that big data can actually offer. On analyzing the healthcare issues, a possible list of challenge is presented below to achieve the aforementioned opportunities.

Scalability: Operating efficiently large amount of medical data (especially image data) and extracting potentially useful information from the data in order to reducemedicalerrorsare crucial jobs. In fact, these two jobs remind us the scalability issue. Accordingly, developing an appropriate model for supporting immediate response of user query is a complex task.

Cost: Analyzing genomicdata itself is a computationally comprehensive task. Now, combining such data with standard clinical data adds extra layers of complexity. Capturing patient behaviouraldatathrough several sensors and analyzing these data are no doubt the big questions.

Security issue: In Healthcare Information System (HIS), security should be the top priorityfrom day one. At any cost, patient data should be protected by adopting intensive physical security, data encryption, user authentication and the latest standard-setting security practices and certifications. In fact, such an issue mainly arises due to the use of cloud (i.e., distributed) computing architecture in HIS because cloud hosts the patient information and provides different services to the authorized users. So, we should pay attention at different levels of health system to impart security in healthcare data [6].

Data standardization and Data structure: The data accessible in the healthcare industry is largely in an unstructured format which is in the format of graphs, prescription notes, images. Leveraging the patient/data correlations in long-term records. And understanding unstructured clinical notes in right context. This lack of data standardization also causes problems in transfer of that data [16].

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To succeed, big data analytics in healthcare needs to be packaged so it is menu-driven, user-friendly and transparent. Real-time big data analytics is a key requirement in healthcare. The fall off between data collection and processing has to be addressed. The dynamic availability of numerous analytics algorithms, models and methods in a pull-down type of menu is also necessary for large-scale adoption. The important managerial issues of ownership, governance and standards have to be considered. And woven through these issues are those of continuous data acquisition and data cleansing. Health care data is rarely standardized, often fragmented, or generated in legacy IT systems with incompatible formats [3].

Assembling, assimilating and analyzing data can be a complex task because the data resides in many internal and external locations and its level of quality may be unknown [7]. As progress is made toward initiatives such as electronic health records (EHR), more and more external data will become available, and this will become an integration challenge. External sources include the National Health Information Network (NHIN), health information exchanges (HIE), health information organizations (HIO) and regional health information organizations (RHIO). As sources and volume of information increase, so will expectations [9].

The cloud makes disclosing and sharing big data easy and relatively inexpensive. However, significant security and privacy concerns exist, including the Health Insurance Portability and Accountability Act (HIPAA). A credentialing process could facilitate and automate this access, but there are complexities and challenges. Since providers, patients and other interested parties such as researchers need secure access; data access should be controlled by group, role and function. The biggest obstacle to effective use of big data is the nature of healthcare information. Payers, providers, research centers and other constituents all have their own granary of data. Even integration is difficult because of concerns about privacy and propriety, the complex and fragmented nature of the data, as well as the different schemas and standards underlying the data and lack of metadata within each granary. The security of the data once it leaves the cloud needs to be assured [9].

It may be that the more astute approach is to enact against misuse of data as opposed to prescribing allowable uses. The debate on data protection and open access should come to an ethically-based consensus agreement, allowing for the views of minorities to be respected, if the right of citizens to appropriate data protection is to be appropriately balanced against their right to further improved healthcare based on patient data-facilitated clinical research. This balance is decisive if legislators wish to avoid overprotection of the rights of a minority becoming pernicious to the delivery of effective healthcare for the majority [17].

In the end, it is not just about images and large data files, but the increasing data sets being developed from many sources across the healthcare spectrum: medical records, data from remote monitoring and genetic information, etc. The challenge is not just in storage and access, but in making this data usable. Healthcare organizations are overpowered, and are not able to consolidate all this data for business intelligence and analytics [18]. The problem in healthcare isn't the lack of data but the lack of information that can be used to support decision-making, planning and strategy [9].

IX. CONCLUSION

Big data analytics has the potential to revamp the way healthcare providers use refined technologies to gain intuitions from their clinical and other data repositories and make abreast decisions. Compelling integration of data mining and medical informatics and its ensuing analysis using big data techniques will no doubt boost healthcare delivery-cost and improved healthcare results via well-informed decision making [6]. In spite of many opportunities and approaches for big data analytics in healthcare presented in this work, there are lot of directions to be scrutinized, concerning various aspects of healthcare data, such as the quality, privacy, timeliness, guaranteeing privacy, safeguarding security and so forth. Computational health informatics in the big data age revealing itself and is highly crucial research field with a potentially momentous effect on the typical healthcare industry [16]. In the future we will see the expeditious, widespread implementation of big data analytics across the healthcare organization as well as in healthcare industry [3]. The upsurge of data has induced this shift in the healthcare sector and not only does it concern

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the healthcare industry but also lead growth potential for the IT sector. Although several challenges and impediment needs be overcome, there is scope for an enormous advancement in healthcare and platforms of analytics [17].

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