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Covid-19 Pandemic: The Role of Data-Driven Interventions in Healthcare Operations Management

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Abstract
This paper discusses the role of data-driven technologies in managing healthcare operations and systems. The study is theoretical. It explores the novel applications of digital technologies such Big Data, AI, 3D Printing, and Block-chain and the most challenging parts of data security, privacy, and interoperability in healthcare operations management. The review outlined six principal facets namely: hospitals practices, clinical services, patients' home, nursing homes, rural areas, and anywhere, which provided the useful insights and the journey involved in the emergence of data-driven technologies for healthcare practices. The study reviews several adaptations/applications, conceptual standpoints, and sub-themes; which were generated from seventy articles in forty journals, written between 2010 and 2022. Overall, there is a considerable consensus across current literature that digital/data-driven technologies extend far beyond mitigating the significant impacts of corona virus on Healthcare operations. They have the potential to deliver more responsive solutions to the management crises that healthcare has been characterised, such as high demands of rising aging populations with chronic diseases, child mortality and potential impacts of pandemics.

Keywords: *Data-driven technologies; Healthcare operations management; Internet of Things; COVID-19 Response.*

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I. Introduction

Healthcare supply chain operations have become increasingly more difficult to manage due to high demands of aging populations with chronic diseases, child mortality and frequent impacts of pandemics such as COVID-19 (Farahani et al., 2017). The pandemic had devastating effects that cut across industries and businesses and nations, even as the effects are still evolving (Ogbuke et al.,2020; Okeya-Olayinka & Ogundele, 2022). According to Manero et al. (2020), coronavirus pandemic has led to a growing surge of patients requiring care; which has led to the issue of data management in global healthcare operations that has become more challenging, with the recent pandemic outbreak. This is more so in the track/trace of data, as infected patients could be either asymptomatic (no detectable sign of symptoms) or symptomatic - with mild fever, sore throat and cough, as well as severe clinical symptoms like pneumonia, respiratory failure and, ultimately death. In addition, Manero et al. (2019) have highlighted that healthcare industry is a data-intensive clinical environment where a huge amount of data is generated, accessed, transferred and shared for essential clinical decision making.

Therefore, as hospitals face littler resources to admit, treat, operate, or monitor the increasing number of patients, and as the numbers of adults over 60 years of age grow globally from 841 million in 2013 to over two billion by 2050 (Miorandi et al., 2012; Farahani et al., 2017), yet, the world relics in the traditional model of hospital-centric care, in which citizens visit doctors when they are sick; a model that is most reactive rather than proactive, and does not often involve patients as an active part of the medical process. The need arises for a model of healthcare operations that is patient-centred and data-driven; which ensures smoother operations of the industry and focuses on patients' individual healthcare needs, and could operate in the contactless mode.

The model will be dependent on smart digital technologies using Big Data Analytics, Artificial intelligence (IA), Internet of Things (IoT), Blockchain, as well as the miniature wearable bio-sensors for personalised Electronic Health Records (EHR) (Manero et al., 2020). More importantly, the supply chain disruptions caused by the covid-19 pandemic and post-pandemic recoveries provided indisputable evidence for the urgent needs of digital techniques for mapping healthcare supply chain networks to ensure greater visibility (Ogbuke et al., 2020).

As such, the benefits of innovative digital applications are immense, but are faced with the challenges of regulations, transparency, scalability, liability, and data leakage. Additionally, handling and streamlining the e-Health records in a secure manner will pose a challenge since the data is spread across space, time and facilities. For instance, some scholars contend that most big data studies in healthcare operations concentrate on technology options of it rather than as a decision making skills (Senthilkumar et al., 2018). Also, healthcare operations management has not been quick enough to adapt to the big data movement compared to other industries. As such, Sengupta et al. (2020) opined that the current electronic health and medical records fall short in providing transparency, traceability and trusted confidentiality of patients' personal information.

This paper therefore reviews the existing and evolving developments in the application of digital tools for enhanced healthcare operations management and seeks to address the following questions.

1. What are the operational challenges in healthcare data-driven innovation and management?
2. How far could data be extracted from healthcare electronic records system and evaluated in real-time through digital technologies?
3. How could feedback in clinical contexts be enabled and incorporated into COVID-19 pandemic response?

In general, there is interesting evidence that researches conducted in healthcare industry particularly on data-driven technology are quite limited and have fluctuated tremendously. For example, the number of articles published has decreased from 134, 000 in 2011 to 75,000 in 2014, but have surged again to 97,000 in 2015 (Farahani et al., 2017). The latest article accepted for publication at the time of this study was titled: ''Blockchain for Healthcare Data management: Opportunities, Challenges and Future Recommendations (Yaqoob et al., 2021).'' This clearly shows that there are still lots of demand to increase research output in healthcare data-driven innovations. This theoretical review leads further discussion in emerging healthcare operational research.

The rest of the study is organised a follow: In section 2 we analyse the recent literature on healthcare operations and supply chain management, including the emerging applications and challenges. Section 3 explains the methodology of the research, while section 4 reports the results. Section 5 presents the conclusions and suggestions for future research.

II. Literature Review

Healthcare Industry is one of the world's biggest and constantly involving industries. In recent years, the industry is changing from a disease centred to a patient-centred model, from volume based to a value-based healthcare delivery model (Cortada et al., 2012). Similarly, in terms of its data management and operations, there are high demands for digital data-driven innovations (Yaqoob et al., 2021). The recent research conducted by IDC (2019), predicted that the worldwide big data expenditure in the healthcare business has progressed towards Compound-Annual Growth Rate (CAGR) of 42% from 2014 to 2019. Rahaman (2020) confirm that global healthcare supply chain is expected to hit $3 billion by 2025. The author classified the global supply chain into diverse range of segments, including pharmaceuticals, information technology, medical devices, and several other services, all of which are growing exponentially.

Several studies have also suggested that technologies such as 3D printing, Big data, AI, and industry 4.0 can be used to manage the impact of COVID-19 pandemic, particularly in the healthcare sector. In fact, these studies confirm that such technologies would help the healthcare supply chain to ramp up the production of Personal Protective Equipment (PPE), Mechanical Ventilators, and other essential items (Chowdhury et al., 2021). Some other studies have predicted the role of other emerging digital techniques such as block-chain, Internet of Things (IoT) and robotics. The studies encouraged healthcare researchers to investigate the prospects of these data-driven innovations in healthcare operations management. These research gaps are in line with research questions outlined earlier, which this review study seeks to explore.

To envision the roles of digital data-driven technologies, it is important to identify the operations and classification of the industry. The healthcare industry is classified into three areas: large healthcare organisations such as hospitals; small clinics and dispensaries; and non-clinical environments such as patients' homes, community nursing homes, and rural areas without any medical support. According to Farahani (2017), healthcare professionals across the globe are connected via IoT eHealth ecosystem to enable patients have more access to international facilities at their fingerprints (anywhere, any time). Moreover, there is also an increasing interest in mobile healthcare clinics across the globe. For example, in African and most developing countries, mobile clinics have proven to offer a low-cost, high quality care for vulnerable populations in remote areas where citizen have no access to basic medical facilities (Farahani., et al., 2017). As mobile clinics are vehicles with limited medical facilities, IoT could make a big difference in enhancing the infrastructure of the mobile

clinics that could partner with large hospitals to remotely communicate for diagnosis and decision support. As such, mobile clinics could scale up their capabilities for care services.

SenthilKumar et al. (2018) stated that the need for data in healthcare organisations is growing in leaps and bounds. They emphasise that to provide effective patient-centred care, it is essential to manage and analyse huge health operations data, especially now that the variety and volume of data sources have increased tremendously in the last two decades, and skyrocketed by Covid-19 pandemic. Rahaman (2020) acknowledged that the recent crisis of COVID-19 has also forced many organisations - public and private, to rethink their policies and strategies. The rapid evolution of the virus requires collective/global strategies. Panhuis et al. (2018) acknowledged that decisions on global health could affect the lives of millions of people and change the future of entire communities. For example, the decision to declare a particular viral disease pandemic, like the recent COVID-19, gives governments and international agencies the opportunity to design some form of restrictions/measures to curtail the spread. A case in point is the different tiers of lockdown measures introduced to fight the corona virus pandemic, including the stockpiling of Personal Protective Equipment (PPE).

In the circumstance, firms that were resilient and agile enough, made patriotic sacrifices by switching production lines to manufacture some essential materials in support of country and humanity. For example, Tesla, General Motors, Ford, Dyson, and Roll-Royce switched to manufacture some critical short supplies especially mechanical ventilators (Bhaskar et al., 2020). Moreover, Public/Private Partnerships (PPP) with Pharmaceutical companies massively produced vaccine. There were also some economic incentives and safety-nets were put in place in support of businesses, employees and the jobless to mitigate the pains orchestrated by the deadly virus.

Imagine the vast resources that could be misapplied/wasted if the decision to announce the pandemic outbreak was based on panic/false alarm rather than being data driven. Panhuiset al. (2018) recognised that decision making in global health is often made under uncertainty and incomplete information. However, the emergence of data-driven mobile technologies including electronic health records and remote sensing create golden opportunities for data-driven decision making in global healthcare operations. In any case, there are multiple layers of challenges, ranging from technical to ethical barriers that could limit the space for effective applications (Drysdale et al., 2019). Integrating data sources can be a daunting task, especially since global health data are often stored in domain-specific data silos that each uses different formats and content standards. The heterogeneity of data slows down scientific progress through time spent on data discovery and curation (Forbes Magazine, 2016). Drysdale et al. (2019) also highlighted the ethical challenges posed to digital technologies including machine learning, data security, privacy concerns, as well as scalability. They maintain that in order to address each of these issues, there should be a discussion among stakeholders and experts to establishing standard frameworks. The study outlined some emerging digital applications in healthcare operations management to mitigate Covid-19 effects.

The growth of Industrial Internet of Things (IoT) has increased the applicability and transformation of big data analytics across industries such as healthcare sector (Groves et al., 2013; Benzidia et al., 2016). A good example is in pharmaceutical sector, where big data and mobile health are starting to transform the healthcare and diagnostics in a significant way, with new players such as Apple and Google acting as increasingly disruptive catalyst (Ogbuke et al, 2020).

Senthilkumar et al. (2018) have also noted that big data is used during all pharmaceutical development, particularly for drug delivery. The authors gave example of how Pfizer has recently initiated Precision Medicine Analytics Environment program that associates the dots among electronic medical record data, clinical trials, and genomic to identify chances to rapidly convey innovative medicines for particular patient populations. Another example of big data application is the utilisation of enormous volume of information from patient data by scientist to detect drug interactions, design and implementation of optimal drug therapies (Tao et al., 2018; Suciu et al., 2015). Senthilkumar et al. (2018) predicted that in near future, big data-derived influences would enable more suitable diagnostics assistance for patients.

Similarly, Yalamanchili et al. (2012) predicted that big data application will play a major role in predicting and preventing human cancer. A study conducted by Oracle indicated that healthcare providers earn only an average of $70.2 million annually, about 15% of potential revenue per hospital, because of their inability to interpret and translate data into actionable insights, as well as due to poor quality of the large volumes of data collected (Lewis, 2019). Nevertheless, hospitals have benefited greatly from the emergence of new IT tools with high added value such as Radio Frequency Identification (RFID), Enterprise Resource Planning (ERP), mobile applications and telemedicine. Telemedicine is one the first and famous stakeholders of IoT, moreso today because of a large portion of world's population that owns smartphones, not just as a communication device, but are deployed for connecting with other sensors (Farahani et al., 2015). Challenges abound related to technology design, acceptance and regulations for data security and privacy as well as system efficacy and safety. Every single digital tool present risks that could be exploited to either help or harm the end-users, especially their privacy, through unauthorised access and authentication (Suciu et al., 2015).

The handling and streamlining of e-Health and Medical Records in a secure manner creates challenges due to data is dispersed across various medical facilities. There are concerns on eHealth data management ranging from scalability, regulation, inter-operability, man-network-machine conflicts, data security, privacy, and ethics. As data grows in variety, volume and velocity, network infrastructure needs to be scalable, whilst interfaces are simple, genuine and accessible for everybody to seamlessly receive, process, store, and communicate.

As the protection of the IoT ecosystem is a sophisticated and challenging task, Ogbuke et al. (2020) recommended that in order to prevent vulnerable attack, network cloud and acting agents must be enhanced by life cycle secure hardware and training of data handlers starting from specification through to implementation and deployment.

Overall, society is yet to fully grasp with many of the ethical and economic considerations associated with IoT, AI and Big Data, Blockchain technologies and their wider implications on human life, culture, sustainability, and technological transformation. To this end, healthcare organisations and technology companies are initiating sustainable partnerships to ensure that these disruptive technologies are deployed in a manner that promotes and guarantees the duty of care and patient integrity/freedom.

The fore-going literature review has responded to the study questions posed in section 1 as follows.

1. The review discussed the concept, prospects and benefits of data-driven technologies for healthcare operations and supply chain management.
2. It identified the emerging applications and the associated challenges ranging from security, privacy to issues of scalability, regulations, and interoperability
3. It outlined the current and future perspectives of digital technologies in healthcare operations management post the Covid-19 pandemic.

III. Methodology

A comprehensive analysis of secondary data in journal and related articles on Big Data, AI, 3D printing, Blockchain, IoT, Medical Healthcare Records data practices, as well as the impacts of digital tools in mitigating Covid-19 pandemic health-related concerns were carried out. The review employed a diverse set of keywords, as well as some inclusion and exclusion criteria for the literature search that gave a clue, clear focus and direction for the study. The following keywords and Inclusion/Exclusion criteria were applied.

1. Databases	Scopus was chosen as it offers integrated results from diverse databases, including Tailor and Francis, Elsevier, Science Direct, Emerald, and Ebsco.
2. Article quality	This paper addressed the quality and relevance of issues discussed by considering only articles that originate from ABS Journal ranking and SSCI index (impact factor).
Review scope	The review chose a twelve ten year timeline from 2010– 2022; which effectively captured developments before and fully after the corona virus pandemic. This choice supports the research objective.
Keywords	Data-driven technologies; Healthcare data management; Industry 4.0; Internet of Things; Ethical health; Covid-19 pandemic, Covid-19 healthcare management.
Article selection criteria	The principal criteria include articles with good empirical characteristics, including quantitative survey, case study and conceptual model development, reviews that focused on data-driven technologies, and application, and associated security, privacy, and ethical challenges.
Article de-selection criteria	In line with the study objectives and review scope, the articles papers that were inherently speculative and those based on stochastic/mathematical models were excluded from the review. Articles that have no healthcare operations and/or supply chain management were also excluded.

Initially, over three hundred articles were obtained using the keywords from leading journal articles. The articles not in the English language were discarded. A preliminary screening was performed on each article by assessing the title and abstract to filter on the basis of relevance to the study objectives. This process synthesized the main themes investigated including the context, content and theoretical underpinnings. The screening generated one hundred and ten articles. Rigorous analyses of these articles were performed to limit the

conceptual boundary to Data-driven technologies, Healthcare operations management, Industry 4.0, Internet of Things, Ethical health, and Covid-19 pandemic/interventions. Repetitive and similarity articles were removed, leading to seventy most relevant articles from forty leading Journals (see Table 1).

Table 1: Classification of the articles reviewed

Journal (SSCI and ABS ranking)	Count	Journal (SSCI and ABS ranking)	Count
Journal of the American Medical Informatics Association	4	American Jrnl of Theoretical & Applied Business	1
Neural Computing and Applications	1	Journal of Big Data	2
Journal of Production Planning and Control	2	IEEE Systems Journal	2
Journal of Healthcare	1	Digital Technology	1
Supply Chain Forum: An Intal Journal	4	AI in Medical for Kids	2
Annals of Operations Research	2	Computer and Biomedical Engineering	1
Research and Applications	1	Journal of Healthcare Engineering	3
Journal of Cryptography	1	Public Policy	2
International Journal of Environmental Research and Public Health	3	New Horizons for a Data-Driven Economy	2
Bioscience Trend	2	Journal of International Business Policy	1
Frontiers in Public Health	2	Issues in Information Systems	2
Information Fusion	2	Transportation Research Part E	1
Innovations in Care Delivery	2	Big Data Analytics in Healthcare	2
IEEE Internet of Things	1	Neural Computing and Applications	1
Business Process Management Journal	1	American Journal of Theoretical and Applied Business	1
Journal of Marketing Management	1	Communications for development	2
Analytics in Healthcare	4	Journal of medical systems	1
International Journal of Production Research	2	Healthcare	1
Future Healthcare Journals	2	Journal of Cryptography	1
Waste Management Journal	2	PwC	1

IV. Results

This research conceptualised, developed, and validated the dimensions of data-driven innovations for healthcare data applications management, and data security, data privacy, as well as interoperability and regulatory challenges in 70 articles. The results reveal that the largest number of 50 articles relied on the researchers' opinions and perspectives as the main methods of investigations. The researchers specifically, provided their perspectives and opinions on the potential impacts of Covid-19 pandemic and data-driven innovations for healthcare operations management. A thematic landscape was identified alongside the major themes and subthemes. Table 2 provides a summary of the specific conceptual underpinnings in the thematic landscape.

Table 2. Thematic landscape: Functions, Operations and Applications.

Functions and Operations.	Applications
1. Pharmaceuticals. The study found that healthcare operations is utilisation an enormous volume of information from patient data to detect drug interactions, design and implement optimal drug therapies In this regard, the growth of Industrial Internet of Things (IIoT) has increased the applicability and transformation of big data analytics in pharmaceuticals and drug prescriptions, as well as across most healthcare functions.	Several researchers (Kuo et al., 2017; Rahaman, 2020) acknowledged the application of big data in pharmaceutical sector. Similarly, other scholars (Ogbuke et al., 2020) confirm that mobile health are starting to transform healthcare diagnostics in a significant way, with new players such as Apple and Google acting as increasingly disruptive catalyst. Senthilkumar et al. (2018) have noted that big data is used during all pharmaceutical development, particularly for drug delivery. The authors gave example of how Pfizer has recently initiated Precision Medicine Analytics Environment program that associates the dots among electronic medical record data, clinical trials, and genomics to identify chances to rapidly convey innovative medicines for patient populations. Aimar et al. (2019) In his study proposes that 3D printing plays a range of roles in clinical pre-operative evaluations.
2. Anywhere/Remote/Home care One of the emerging models for healthcare today is caring for patients at home and away from the hospital/clinic.	Farahani et al. (2015) and Senthilkumar et al. (2018) reviewed the definition, process, and applications of big data in remote healthcare management. They saw IoT as a convergence of sensors, wearables, actuators, telecom systems and cloud computing, interconnecting through the internet to provide goal-oriented services. Specific applications include using wearable wrist watches and sensors by the patients to monitor and to detect heart rate, glucose level and blood pressure, and

This model was not designed to eliminate hospitals/clinics. Instead it leverages them in the share model for patient care. To integrate hospital or clinics with remote patients, the IoT ecosystem has created smart or automated homes that enable self-testing, confidentiality and wellbeing. Smart homes could adjust lights and sound to avoid sensory overloads for individuals with autism	integrating the information into patients' electronic health and medical records for easy analysis, diagnosis and treatment. Yalamanchili et al. (2012) predicted that big data application in proteomics will have a major role in predicting and preventing human cancer. Some other emerging applications include smart toilet to execute urine testing on regular basis for preventive and primary care, the convergence of smart traffic lights and ambulance routing to save lives with the cooperation of transportation infrastructure. Shah et al. (2018) identify gaps and future research directions related to technology design and acceptance, regulations for data security and privacy, and system efficacy and safety. Aimar et al. (2019) also noted that 3D Printing technology represent a big opportunity to help pharmaceutical and medical companies to create more specific drugs, enabling a rapid production of medical implants and changing the way that doctors and surgeons plan procedures. Manero et al. (2020) emphasis that 3D Printing is used in producing a variety of equipment for hospitals including face shields, masks, and even, ventilator for components to handle the surge.
3. Telemedicine Telemedicine is one of the first and famous stakeholders of digital techniques for Healthcare electronic data management. It is vital for elderly and less able individuals patients with chronic diseases. In telemedicine, IoT has a lot to offer since a large portion of the world population own smart phones and other similar devices; which are not just mere communication devices, but connecting with other sensors	Chowdhury et al. (2021) in his studies confirm that such technologies can help the healthcare supply chain immediately to ramp up the production of Personal Protective Equipment (PPE), Mechanical Ventilators, and other essential items (Chowdhury et al., 2021). Other studies also acknowledge that smart phones played a vital role in medical field in enabling patients to self-test their own health, particularly now that self-test data have become important predictors of health and diseases. Additionally, physicians and medical staff have ways of seeing their patients virtually via teleconferencing. More so, IoT could further augment telemedicine by networking sensors to facilitate tele-screening. In this way, the hospital still could cope with a smaller number of health workers by increasing the virtual care services.
4. Mobile Clinics There is an increasing demand and adoption of in rural areas especially in developing countries. In African, mobile clinics are proved to offer a low-cost, high quality care for vulnerable populations in remote areas where citizens have no access to basic medical facilities. Mobile clinics are vehicles with limited medical facilities that could partner with large.	Ali et al. (2020) and Senthilkumar et al. (2018) in his research predicted that in near future, fresh big data-derived influences will prompt suitable updates of diagnostic assistance, clinical guidelines and patient triage that permit more particular modified treatment, and advance medical results for patients. Data-drive technologies like IoT, Big data, and AI could make a difference in enhancing the infrastructure of the mobile clinics, which could partner with large hospitals to remotely communicate for diagnosis and decision support.

This paper has presented the evidence on how Covid-19 has exacerbated data crises in healthcare operations management, and the need/opportunities for rapid adoption/application of a wide range of digital/data-driven technologies across major functional divisions within the healthcare industry. The applications as summarized in Table 2 include health monitoring, diseases detection/treatment, system security, smart hospitals and remote/emergency response.

The opportunities and challenge emanating from covid-19 varied widely across national and regional contexts in accordance to differences in infection rates and the socio-political will to respond (Chowdhury et al., 2021). The same applies to literature development on the subject matter of this study, as seen on Table 3, with most of the review articles emanating from the advanced and emerging economies.

Table 3: The national and geographical contexts on which the reviewed articles focused

Country	Economy	Number of Articles	References
Central European countries	Advanced	3	Ogbuke et al. (2020); Dash et al. (2019); Mathy et al. (2020)
South Asian countries	Emerging	3	Zhang et al. (2015); Bhaskar et al. (2020); Wang et al. (2019)
Multiple countries from various continents	All types	9	Bourlakis et al. (2016); Daecher et al. (2018); Miorandi et al. (2012); Suciu et al. (2015); Tao et. (2018); Ali et al. (2020); Bhaskar et al. (2020); Aimar et al. (2019); Angraal et al. (2017)
Canada	Advanced	2	Ageron et al. (2018); Drysdale et al. (2020)
Algeria	Developing	1	Schiopoiu et al. (2020)

India	Emerging	1	Senthilkumar et al. (2018)
Ireland	Advanced	2	Farahani et al. (2015); Cavanillas et al. (2016)
United States of America	Advanced	5	Shah et al. (2018); Davenport and Kalakota (2019); Manero et al. (2020); Zhang and Koru (2020); Panhuis et al. (2018)
Australia	Advanced	1	Chowdhury et al. (2021)
UAE	Emerging	2	Zobbi et al. (2020); Yaqoob et al. (2021)
Italy	Advanced	1	Aimar et al. (2019)
Greece	Advanced	1	Siyal et al. (2018)
Sweden	Advanced	1	Rahaman (2020)
Germany	Advanced	1	Ivanov and Dolgui (2020)

V. Discussion

This study presents a comprehensive and systematic review of existing and future research perspectives in data-driven technology for healthcare practices and operations. The paper also explored the most challenging parts of digital technology applications in healthcare data privacy, data leakage, data security, scalability in terms of efficient handling of large volume of electronic health and medicaldata records, as well as interoperability and regulatory concerns, not only to healthcare organisations but the vulnerable populations. We also assessed the novel applications of digital technologies such Big Data, AI, 3D Printing, and Blockchain technology across the major facets namely: hospitals practices, clinical services, patients' home, nursing homes, rural areas, and anywhere, which provided useful insights into the present and what the future portends.

These principle facets are built across the multiple levels and unique conceptual standpoints indicated by 10 sub-themes. These themes were generated based on 70 articles (2010 -2021) drawn from 40 leading Journals. This research is very novel and is one of first studies, to the best of our knowledge, which systematically synthesized and analysed both the prior and most recent discussions on electronic health and medical data records, as well as digital applications in response to the sweeping crisis of Covid-19 pandemic. This paper comprehensively explored the current digital applications, as well as the potential prospects, including the industry 4.0, following a well-designed thematic landscape and conceptual articles streams. Again, most of the existing research work focused more on the traditional healthcare data practices, with limited information on today's emerging models for healthcare - Patient-Centre Care (PPC). The model focuses on the patients and their individual healthcare needs, with potentials to integrate hospital and clinics with patients in PCC, thereby utilizing the powerful ecosystems of IoT, digital tools, both in smart homes and in self-testing.

Most reviewed research work often justified the traditional approach, because of the associated data security, data leakage, and data privacy challenges of digital innovations on the vulnerable individuals. Other justifiable factors include cost implications posed to healthcare organisations, in terms of maintenance and managing the electronic health and medical records. Other scholars have also noted that the interactions in supply chain for vast majority of enterprises are going unmonitored, and have created silos along the operations processes, resulting in businesses inefficiency. They argue that the usage and exploitation of these unmonitored and unstructured massive data information by digital technologies may have also illustrated the value creating possibilities of data-driven innovations for business decision-making skills.

In general, the systematic rigor adopted in this study is more evident, particularly in clear recognition of these most challenging issues of data security, data privacy and their impact on individuals' freedom, transparency, and theramifications to the entire society. More so, the comprehensive review demonstrates clarity, and brought to bear what the issues are, that these emerging innovations will offer proactive and useful data management insights for healthcare organisation's decision-making and better performance

VI. Conclusions And Future Reseach Directions

In this paper, we presented insightful discussions on the integration of digital data-driven technologies with healthcare systems, and highlighted other factors and challenges associated with their diffusion and uptake across the industries. Likewise, the reviewed showed that the number of articles on this subject have been steadily increasing owing to the sweeping health crisis of Covid-19 Pandemic, however, there is absence of systematic literature review that comprehensively explored the existing and potential applications of these digital data-driven innovations in response to the pandemic, and in handling healthcare data crises.

More so, despite the prospects of the applications of AI, IoT, Blockchain, 3D printing and Big Data Analytics techniques particularly, from the perspective of 3Vs (volume, velocity, and Variety), several scholars have acknowledged that the above perspectives remain a largely unexplored in the healthcare industry (Yaqoob, 2021).

This paper identified research gaps and suggested unique research questions, and proffered steps that address these concerns. Additionally, the reviewed articles were categorised according to the national and

geographical contexts. National and geographical context are important factors for developing customised strategy for dealing with covid-19, given that different countries have experienced different infection rates and adopted different lockdown strategies to manage the pandemic situations (Chowdhury et al., 2021). This research is novel in systematically analyzing the prior and most recent discussions on electronic health and medical data records, as well as digital applications in response to the sweeping crisis of Covid-19 pandemic.

We noticed that there are quite limited publications that are available on digital technologies and integrations within the healthcare systems. Likewise, the developing nations are under-represented in this research review as evidence in the national and geographical contexts table, and therefore, more research is needed in this context. There is also interesting evidence that researches conducted in healthcare industry particularly on data-driven technology are quite limited and have fluctuated tremendously. We have also, observed within the literature space that very limited articles have been published since 2015. Hence, there are still lots of demand to increase research outputs in healthcare data-driven innovations.

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